Arch Linux – Setup Guide

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0 INTRO

This **extensive & modular guide** focuses on how to install and set up Arch Linux with the following goals in mind. The system should:

- be as **stable** as possible,
- be sufficiently **secure** (without compromising usability too much),
- have acceptable **low latency** (for real-time applications, including games),
- be **automated** as much as possible (also for a small maintenance of the system),
- be **well set up for** KDE, Gaming, Firefox, mpv, Virt-Manager, your hardware, …

This guide should be very helpful especially – but not only – for Arch beginners.
Many sections (esp. after installation) should be adaptable to other distributions.

0.1 Recommended prerequisites

- Having an UEFI system & a whole drive
- **View:** FAQ & Help:Reading
- For a better understanding of certain steps, **view:**
  - the file system hierarchy overview &
  - the essential core utilities of a GNU/Linux system

0.2 Key features – Realization of goals

0.2.1 Ideal setup of Secure Boot using

- Unified kernel image (UKI) – a single executable which will be booted directly from UEFI firmware (no extra boot manager). Using mkinitcpio as the Initrd generator with systemd init and ukify as the UKI generator.
- Full-disk encryption (FDE) using dm-crypts LUKS2 extension
- Own UEFI SB Keys. Dual booting with Windows is possible.
- Kernel lockdown (but disables hibernation)

0.2.2 File system: Btrfs (Feature overview)

- **System rollback support** if greater system upgrade issues occur
  > Creation of snapshots during pacman transactions using: Btrfs **>** Snapper **>** snap-pac
- Transparent and automatic *zstd* compression
- Hibernation support using swapfile

0.2.3 Low latency

… to match Windows E2E latency.

- **Kernel:** linux-zen
- **Reducing I/O latency:** GameMode, Reduce DRI latency, Disable tear prevention
- **Reducing PipeWire latency**
- **Realtime privileges** with rt module
- **Settings from/for:** Professional audio, Gaming::Improving performance

0.2.4 System Hardening

- **Restrict programs' capabilities:** AppArmor
- **Sandboxing applications:** Firejail (AppArmor is required)
- **Firewall:** Firewalld
- **Kernel Hardening**
- **UEFI Hardening:** Admin Password, IOMMU, SPI Write Protection, etc.

0.2.5 Setup for the following software & hardware

- **Desktop environment:** KDE Plasma
- **AUR helper & Pacman wrapper:** Paru **| Shell:** Zsh
- **Web browser:** Firefox **| Media player:** mpv
- **Office:** LibreOffice, Printer **&** Scanner
- **Virtualization:** KVM/QEMU **>** libvirt **>** virt-manager **| Containerization:** Podman
- **AI / ML:** Ollama, PyTorch, ONNX Runtime for e.g. Firefox AI Runtime, etc.
- **Hardware Security Key (Nitrokey 3):** FIDO2, OpenPGP Card, SSH Key, WebAuthn
- **… and more**

0.2.6 Disk layout

Partition	**1:** EFI system partition (ESP)	**2:** Root partition	
File systems & Labels	└ FAT32 (Unencrypted)	└ "Arch" – LUKS2 encrypted └ "Root" (`/dev/mapper/root`) – Btrfs	
Mount points	`/efi`	`/, /.snapshots, /home, /swap, ...`	

0.3 Styles & Meaning

Style	Meaning
BRICK	<something you probably want to change>
GRAY	<**OPT** = optional, not always a good option>, <**ALT** = alternative>, <not necessary>
DARK RED 2	<ATTENTION>
RED	<BAD>, <You can really mess up>, <~~deletions~~>
GREEN	<OK>, <already good adjustment>, <additions>, <uncomment>
GOLD, **BLUE**, **BOLD**	For highlighting
`command;`	
> … (one line)	Insert …; Next step(s)
> … (more lines)	Insert …; Next step(s)

0.4 Notes

- **Get the current version** of this guide
- This guide is a marathon – not a sprint. It is advisable to read a chapter completely before starting the next one.
- This guide is modular. For example, if the "Ideal Secure Boot Setup" is not desirable, skip certain steps and rename `/dev/mapper/root` to `/dev/nvme0n1p2` throughout this document.
- You should first perform the installation in a VM using e.g. VirtualBox or QEMU/KVM.
- **Disclaimer:** This document is often adapted from the official ArchWiki ⇨ General disclaimer.

0.5 Support me

If you find my guide helpful, then that's great. However, a lot of working time went into it.

Therefore, a little support from you would be greatly appreciated:

- If you have any **suggestions for improvement**, please let me know. For example, when commands no longer work because their parameter names have been changed.
- You can also support my work by **donating** ComputerBase Pro or a Steam Card.

1 Pre-boot

1.1 Acquire an installation image

https://archlinux.org/download/ **> See:** HTTP Direct Downloads

1.1.1 Download: Image, Signature & Checksum file

- **ISO:** `archlinux-version-x86_64.iso`
- **PGP signature:** `archlinux-version-x86_64.iso.sig`
- **Checksum file:** `b2sums.txt` (ALT: `sha256sums.txt`)

1.1.2 Verify checksum

```
b2sum --ignore-missing -c b2sums.txt
> <ISO>: OK
```

1.1.3 Verify signature (using sequoia-sq)

https://gitlab.com/sequoia-pgp/sequoia
ALT: https://wiki.archlinux.org/title/Installation_guide#Verify_signature

```
sq network wkd search pierre@archlinux.org --output release-key.pgp;
sq verify --signer-file release-key.pgp --signature-file archlinux-version-
x86_64.iso.sig archlinux-version-x86_64.iso;
```

1.2 Prepare the USB flash installation medium

Other tools: https://wiki.archlinux.org/title/USB_flash_installation_medium

Note: Plug the USB stick directly into the mainboard.

1.2.1 a) In GNU/Linux – Example (using dd)

Note: It is highly recommended to use tools like `isoimagewriter`.
Note: Replacing `/dev/sdX` with your unmounted USB drive (**See:** `lsblk`)!

```
dd bs=4M if=/path/to/archlinux-version-x86_64.iso of=/dev/sdX conv=fsync
oflag=direct status=progress
```

1.2.2 b) In MS Windows – Example (using Rufus)

Download & Start Rufus:
- **Select:** ISO & USB drive
- **Target system:** UEFI
- **Partition scheme:** GPT

Note: If the USB drive does not boot properly using the default ISO Image mode, **DD Image mode** should be used instead.

1.3 Set up UEFI

1.3.1 Update UEFI firmware

Usual procedure:

- **Download** latest stable UEFI firmware **& Copy** file to a FAT32 formatted USB stick
- **Boot into the UEFI firmware setup utility** often by pressing [F2] after POST
  - **Reset** UEFI settings [F5]
  - **Update** the UEFI firmware & wait for completion
  - **OPT:** Reset UEFI settings

1.3.2 UEFI settings

- **Boot into UEFI firmware setup utility**

1.3.2.1 Basic

- **Disable Secure Boot.** Later we will set that up
- **Disable CSM** (Compatibility Support Module) for "UEFI only"
- **OPT: Disable Fast Boot** for full initialization

1.3.2.2 Save settings & Reboot

- **Save settings & Reboot** (often [F10])

1.4 Notes for MS Windows dual booters

https://wiki.archlinux.org/title/Dual_boot_with_Windows

- **First install Windows** on a separate drive, otherwise Windows will use Archs ESP.
  ALT: Remove the Linux drive during the Windows installation.
- **Disable Fast Startup** & Hibernation
- **Use UTC** instead of localtime
- **Disable your Linux disks** in the "Disk Management utility" by taking the disk *Offline*! Do not create a (new) GPT!

1.5 For Oracle VM VirtualBox: Port Forwarding

Network settings > Advanced: **Port Forwarding:**

- **Host** port: *3022*
- **Guest** port: 22

2 Pre-installation

2.1 Boot from USB flash installation medium

Note: Press vendor specific key after POST to open the UEFI boot menu (often [F8] or [F12]).
ALT: Set boot order in UEFI firmware setup utility.

2.2 Set the keyboard layout

Note: Default locale is Germany (de_DE).

Available layouts: `localectl list-keymaps`

Note – en ← de: | y ← z | - ← ß | / ← - | \ ← # | : ← ö | ^ ← & |

```
loadkeys de-latin1
```

2.3 Verify the EFI-boot mode

Check UEFI firmware bitness:

```
cat /sys/firmware/efi/fw_platform_size
```

> Output: 64 or 32

2.4 Verify internet connection

```
ping -c 4 archlinux.org
```

> Error?: https://wiki.archlinux.org/title/Installation_guide#Connect_to_the_internet

2.5 Set temporary root password (for ssh root login)

```
passwd
```

> *root_password*

2.6 Connect via ssh (as *root*)

https://wiki.archlinux.org/title/Install_Arch_Linux_via_SSH

… to set up Arch Linux via SSH to copy & paste (esp. longer) text without failures.
This guide is very copy & paste friendly (using the ODT file)!

Note: Repeat these steps later to login as `root` or as *`username`* ("as *user*").

2.6.1 Later after reboot: Start ssh daemon

```
systemctl start sshd.service;
```

2.6.2 For Oracle VM VirtualBox: Connect

```
ssh -p 3022 root@localhost
```

2.6.3 Connect to (new) IP address

Note: You may want to remove the fingerprint(s) from last session in `~/.ssh/known_hosts`, using:

```
ssh-keygen -R 192.168.X.Y
```

Get IP address (e.g. 192.168.*X*.*Y*):

```
ip -br addr
```

Connect:

```
ssh root@<ip_address>
```

2.7 Preparing the disk

Note: The drive should be connected directly to a SATA/NVMe/… interface. Issuing the Secure Erase/Format/Sanitize command on a drive via USB or a SAS/RAID card could brick the drive!

2.7.1 Identify your disk/drive

https://wiki.archlinux.org/title/Device_file

Note: NVMe SSDs are named: nvme***D***n***N***p***P*** (***D*** ∈ {0, 1, 2, …}, ***N*** ∈ {1, 2, …}).
Other drives are often named: sd***DP*** (***D*** ∈ {a, b, …}).
… ***D***evice**,** ***N***amespace**,** ***P***artition ∈ {1, 2, …}

```
lsblk -f
```

> */dev/nvme0n1* is our disk **< CHANGE** this accordingly in this whole document

Example: Your disk is *vda* (or *sda*, *sdX*, …)

- Replace *nvme0n1**p*** with *vda* **AND THEN**
- Replace *nvme0n1* with *vda*

2.7.2 OPT: Update firmware of the drive

SSD: https://wiki.archlinux.org/title/Solid_state_drive#Firmware
NVMe SSD: https://wiki.archlinux.org/title/Solid_state_drive/NVMe#Firmware_update

2.7.3 Check health of the drive – S.M.A.R.T.

2.7.3.1 For NVMe

https://wiki.archlinux.org/title/Solid_state_drive/NVMe#SMART

```
nvme smart-log -H /dev/nvme0n1
```

2.7.3.2 For non-NVMe (using smartmontools)

https://wiki.archlinux.org/title/S.M.A.R.T.#smartctl

2.7.3.2.1 Check if SMART support is "Available" & "Enabled"

```
smartctl --info /dev/sdb | grep 'SMART support is:'
```

> Available but not enabled?:

```
smartctl --smart=on --device=ata /dev/sdb
```

2.7.3.2.2 Run a self-test

Available self-tests: `smartctl -c /dev/sdb`

```
smartctl -t short /dev/sdb
```

OPT – Check transportation damage to the HDD:

```
smartctl -t conveyance /dev/sdb
```

2.7.3.2.3 View test results

```
smartctl -l selftest /dev/sdb
```

2.7.4 (Secure) Erasure of the drive

https://wiki.archlinux.org/title/Dm-crypt/Drive_preparation

2.7.4.1 Wipe old LUKS header (if LUKS encrypted before)

https://wiki.archlinux.org/title/Dm-crypt/Drive_preparation#Wipe_LUKS_header

```
cryptsetup erase /dev/nvme0n1p2
```

2.7.4.2 Erase all old available signatures

```
wipefs --all /dev/nvme0n1
```

2.7.4.3 Setting the sector/page size to 4 KiB for performance

https://wiki.archlinux.org/title/Advanced_Format

HDDs often report a **logical sector size of 512 B** (for Stone Age compatibility), but use a **larger physical sector size**.

NVMe SSDs report their logical block address size (FLBAS). SSDs smallest unit is a page.

Many filesystems (including btrfs) default to a sector size of 4 KiB for x86_64 (also for cross-architecture compatibility), see **`$ man mkfs.btrfs`**.

⇨ To avoid mapping, **change the sector/page size to 4 KiB**, which should also be closer to the physical sector/page size and thus **improve performance.**

2.7.4.3.1 Check if there is a better logical block address size available (Here: NVMe)

```
nvme id-ns -H /dev/nvme0n1 | grep "Relative Performance"
```

> E.g. 2 supported LBA sizes:

```
lbaf  0 : ms:0   lbads:9  rp:0x2 (in use)
lbaf  1 : ms:0   lbads:12 rp:0x1
```

1. `ms` (Metadata Size) should be `0` (`ms` is not well-supported under Linux)
2. `rp` (Relative Performance) should be the smallest (Here: `rp:0x1`)
   ⇨ **Here:** Change the LBA format with its page size for better performance

   Note: "Data Size" = $2^{\text{lbads (LBA data size)}}$ [bytes] (Here: 2^9 = 512 B; 2^{12} = 4096 B)
   ⇨ **Here:** Change the data size from 512 B to 4 KiB

2.7.4.3.2 Change the logical block address size (Here: NVMe)

```
nvme format --lbaf=<lbaf> /dev/nvme0n1          (Here: 1)
```

2.7.4.4 Memory cell clearing (for SSD)

https://wiki.archlinux.org/title/Solid_state_drive/Memory_cell_clearing

… thus restoring it to its factory default write performance.

Note: Do this only if you have not changed the sector size.

```
E.g.: nvme format --lbaf=<lbaf> /dev/nvme0n1
```

2.7.4.5 OPT: Prevent cryptographic attacks or file recovery (for dm-crypt)

https://wiki.archlinux.org/title/Dm-crypt/Drive_preparation#dm-crypt_wipe_on_an_empty_disk_or_partition

Wipe the disk with crypto-grade randomness **if** the disk contains non-random or unencrypted data.

2.7.4.5.1 Create a temporary encrypted container

https://wiki.archlinux.org/title/Dm-crypt/Device_encryption#Encryption_options_for_plain_mode

Note: Change cipher according to `$ cryptsetup benchmark`

```
cryptsetup -d /dev/urandom --cipher aes-xts-plain64 open --type plain
/dev/nvme0n1 to_be_wiped
```

2.7.4.5.2 Wipe with (encrypted) zeros

```
dd bs=1M if=/dev/zero of=/dev/mapper/to_be_wiped status=progress
```

> WAIT:| 16,67 min/TB @**1 GB/s |** 1,5 h/TB @185 MB/s **|** 2 h/TB @139 MB/s **|**

2.7.4.5.3 Close the temporary container

```
cryptsetup close to_be_wiped
```

2.8 Partition the disk using gdisk – ESP + Root

Modified: LUKS on a partition with TPM2 and Secure Boot
https://wiki.archlinux.org/title/GPT_fdisk
https://wiki.archlinux.org/title/EFI_system_partition#Create_the_partition

Num	Size	gdisk's code	Partition type
1	1 GiB	EF00	EFI system partition
2	100%FREE	8304	Linux x86-64 root (/)

```
gdisk /dev/nvme0n1
>
```

2.8.1 Create the GUID Partition Table (GPT)

https://wiki.archlinux.org/title/Partitioning#GUID_Partition_Table

`o` (New protective MBR)

2.8.2 Create the EFI System Partition (ESP)

`n` (New partition)
`enter` (Partition number: **1**)
`enter` (First sector: …)
`+1g` (Last sector)
`ef00` (**EFI System**)

2.8.3 Create the Root Partition

`n` (New partition)
`enter` (Partition number: **2**)
`enter` (First sector: …)
`enter` (Last sector: <Free Space>)
`8304` (**Linux x86-64 root (/)**; also for LUKS)

2.8.4 Write changes

OPT: Print changes: `p`
Write changes: `w`

2.9 Format & Mount the partitions – Btrfs on LUKS + ESP

https://wiki.archlinux.org/title/Partitioning
https://wiki.archlinux.org/title/Security#Mount_options
https://en.wikipedia.org/wiki/Comparison_of_file_systems

2.9.1 Preparing the LUKS container

2.9.1.1 Create the LUKS encrypted container

https://wiki.archlinux.org/title/Dm-crypt/Device_encryption#Encryption_options_for_LUKS_mode

TODO – OPAL: Add option for self-encrypting drives (SED) using OPAL with `--hw-opal`.
Currently, not for external drives over USB. The OPAL admin user and password must be set.

```
cryptsetup luksFormat --label Arch /dev/nvme0n1p2
> YES
> crypt_password
```

2.9.1.2 OPT: Enable TRIM/discard support (for encrypted SSD)

READ: Discard/TRIM support for solid state drives (SSD)

Warning: Negative security impact because it can make filesystem-level operations visible on the physical device (information leaking filesystem type, used space, etc.). If in doubt, do not enable it.

2.9.1.3 OPT: Verify the sector size used by the LUKS2 volume

https://wiki.archlinux.org/title/Advanced_Format#dm-crypt

… esp. if you have changed the sector size earlier.

```
cryptsetup luksDump /dev/nvme0n1p2 | grep sector
```

2.9.1.4 Open the LUKS container

```
cryptsetup open /dev/nvme0n1p2 root
> crypt_password
```

2.9.2 Preparing btrfs (also for snapper & swap)

https://wiki.archlinux.org/title/Btrfs#Subvolumes
https://wiki.archlinux.org/title/Snapper#Suggested_filesystem_layout

2.9.2.1 Format the (unlocked LUKS) device

TODO: https://btrfs.readthedocs.io/en/latest/Checksumming.html

```
mkfs.btrfs -L Root /dev/mapper/root;
```

2.9.2.2 Mount the top-level btrfs subvolume

```
mount /dev/mapper/root /mnt;
```

2.9.2.3 Create nested btrfs subvolumes (for excludes of snapshots)

… using a *flat* layout (all subvolumes are direct descendants of the toplevel one).

Note: "Snapshotting is not recursive, so a subvolume or a snapshot is effectively a barrier and no files in the nested appear in the snapshot."

```
btrfs su cr /mnt/@;                    # /
btrfs su cr /mnt/@home;                # /home
btrfs su cr /mnt/@snapshots;           # /.snapshots
btrfs su cr /mnt/@swap;                # /swap
btrfs su cr /mnt/@var_cache_pacman_pkg;        # /var/cache/pacman/pkg
btrfs su cr /mnt/@var_lib_machines;            # /var/lib/machines
btrfs su cr /mnt/@var_log;                     # /var/log
btrfs su cr /mnt/@var_tmp;                     # /var/tmp
```

2.9.2.4 Unmount the top-level btrfs subvolume

```
umount /mnt;
```

2.9.2.5 Mount the nested subvolumes

```
mount -o compress=zstd,subvol=@ /dev/mapper/root /mnt;
```

```
mount -m -o compress=zstd,subvol=@home /dev/mapper/root /mnt/home;
mount -m -o compress=zstd,subvol=@snapshots /dev/mapper/root /mnt/.snapshots;
mount -m -o compress=zstd,subvol=@swap /dev/mapper/root /mnt/swap;
mount -m -o compress=zstd,subvol=@var_cache_pacman_pkg /dev/mapper/root
/mnt/var/cache/pacman/pkg;
mount -m -o compress=zstd,subvol=@var_lib_machines /dev/mapper/root
/mnt/var/lib/machines;
mount -m -o compress=zstd,subvol=@var_log /dev/mapper/root /mnt/var/log;
mount -m -o compress=zstd,subvol=@var_tmp /dev/mapper/root /mnt/var/tmp;
```

2.9.3 Preparing the EFI system partition (ESP)

https://wiki.archlinux.org/title/EFI_system_partition#Typical_mount_points

Note: The *esp* will be mounted on */efi* (for UKI).

```
mkfs.fat -F32 /dev/nvme0n1p1;
mount -m -o umask=0077,noexec,nosuid,nodev /dev/nvme0n1p1 /mnt/efi;
```

3 Install essential packages

https://wiki.archlinux.org/title/Installation_guide#Install_essential_packages

```
pacstrap -K /mnt <packages in this chapter>
```

3.1 Basic

https://wiki.archlinux.org/title/Kernel, Benchmarks (2023-01)

- **Base:** `base` `base-devel`
- **Initrd & UKI generator:** `mkinitcpio` `systemd-ukify`
- **UEFI – Secure Boot & TPM2:** `efitools` `sbsigntools` `tpm2-tss`
- **Dependencies:** `iptables` `grencode`

- **Recommended Kernel:** `linux-zen` (Feature List)
- **ALT:** `linux` `linux-hardened` `linux-rt` `linux-rt-lts`
- **OPT – Fallback:** `linux-lts` (Since major kernel upgrades *can* cause issues. **ALT:** Rollback system)

3.2 Microcode & Audio DSP firmware

https://wiki.archlinux.org/title/Advanced_Linux_Sound_Architecture#Firmware

- **Processor Microcode (not for VM):** `amd-ucode` **or** `intel-ucode`
- **For some audio devices (≥2020):** `sof-firmware`
- **For some audio devices:** `alsa-firmware`

3.3 Disk management

- **NVMe:** `nvme-cli`
- **Dm-crypt:** `cryptsetup`
- **Btrfs:** `btrfs-progs`
- **FAT:** `dosfstools`
- **Ext4:** `e2fsprogs` **| exFAT:** `exfatprogs` **| NTFS:** `ntfs-3g`

3.4 Other crucial packages

- **Documentation:** `man-db` `man-pages` `man-pages-de`
- **Network manager:** `networkmanager` (Wiki) (dep. of `plasma-meta`)
- **Pacman tools:** `pacman-contrib` `rebuild-detector` `pkgstats`
- **Console text editor:** `vim` (Wiki)

3.5 OPT: Dynamic Kernel Module Support (DKMS)

`dkms` + Headers according to the kernels to be installed:
`linux-zen-headers` `linux-lts-headers` `linux-headers` `linux-hardened-headers`

4 System configuration

4.1 Generate a fstab file

```
genfstab -U /mnt >> /mnt/etc/fstab;
```

4.2 Set root password using systemd-nspawn

https://wiki.archlinux.org/title/Systemd-nspawn
https://gitlab.archlinux.org/archlinux/arch-install-scripts/-/issues/35

Info: Press Ctrl-] three times within 1s to kill the container.

```
systemd-nspawn -D /mnt passwd
> root_password
```

4.3 Boot into the container

Info:

- An init program is automatically searched for and run as PID 1 in the container. The systemd commands are available in this container for user input validation.
- The used parameters are for efibootmgr --create, hwclock --systohc & timedatectl set.
- /dev/rtc is usually a symlink to the Real-Time Clock /dev/rtc0.

```
systemd-nspawn -b -D /mnt --bind /dev/nvme0n1 --bind /dev/nvme0n1p1 --bind
/dev/nvme0n1p2 --bind /sys/firmware/efi \
--bind /dev/rtc --bind /dev/rtc0 --timezone=off \
--capability=all
```

> Login as root:

- mnt login: ***root***
- Password: *root_password*

4.4 Time

https://wiki.archlinux.org/title/System_time

4.4.1 Set time zone

https://wiki.archlinux.org/title/System_time#Time_zone

Info: When commands output more content than can fit on one screen, they automatically pipe their output through a pager (usually less) to allow you to navigate through the content interactively. **Basic key bindings: | q** = quit **| /** = Search (n=Next; N=Previous) **|**

Available zones:

```
timedatectl list-timezones
```

Set time zone:

```
timedatectl set-timezone Europe/Berlin;
```

4.4.2 Set hardware clock from system clock & Generate /etc/adjtime

Info: The hardware clock is synchronized to the system clock every 11 minutes.

```
hwclock --systohc;
```

4.4.3 Time synchronization (NTP) – systemd-timesyncd

https://wiki.archlinux.org/title/Systemd-timesyncd

```
systemctl enable systemd-timesyncd.service;
```

4.4.4 Verify

```
timedatectl
```

4.5 Locale

https://wiki.archlinux.org/title/Locale

Note: Generate locales if locale-specific formatting or text input are required. Or an app specifically checks a locale. The American-English locale should be generated as a fallback.

4.5.1 Generating locales

Note: The following commands will remove the "#" which uncomments the line. You can also manually edit the files using a console text editor like `vim` or `nano`.

```
sed -i 's|#de_DE.UTF-8 UTF-8|de_DE.UTF-8 UTF-8|' /etc/locale.gen;
sed -i 's|#en_US.UTF-8 UTF-8|en_US.UTF-8 UTF-8|' /etc/locale.gen;
sed -i 's|#ja_JP.UTF-8 UTF-8|ja_JP.UTF-8 UTF-8|' /etc/locale.gen;
sed -i 's|#ko_KR.UTF-8 UTF-8|ko_KR.UTF-8 UTF-8|' /etc/locale.gen;
```

```
locale-gen
```

4.5.2 Locale variables

https://wiki.archlinux.org/title/Locale#Variables

4.5.2.1 LANG: Default locale

Info: This command uncomments `#de_DE.UTF-8 UTF-8` & executes `locale-gen`.

```
localectl set-locale LANG=de_DE.UTF-8;
```

4.5.2.2 OPT – LC_MESSAGES: User interface for message translation

… to prefer American-English for the User interface for better troubleshooting & keyboard shortcuts. **ALT:** Change the XDG user directories to one named in English.

```
localectl set-locale LC_MESSAGES=en_US.UTF-8;
```

4.5.3 VC Keymap & X11 Layout

https://wiki.archlinux.org/title/Linux_console/Keyboard_configuration
https://wiki.archlinux.org/title/Xorg/Keyboard_configuration#Using_localectl

```
localectl set-x11-keymap de pc105 nodeadkeys;
```

4.5.4 Verify

```
localectl
```

4.6 Network

https://wiki.archlinux.org/title/Network_configuration

4.6.1 Set the hostname

https://wiki.archlinux.org/title/Network_configuration#Set_the_hostname

```
hostnamectl hostname hostname
```

4.6.2 Set the regulatory domain (for Wi-Fi)

https://wiki.archlinux.org/title/Network_configuration/Wireless#Respecting_the_regulatory_domain

Note – vim: Press `[i]` to go into **insert mode** to type, and `[ESC]` to go out into **normal mode**.
Note – vim (normal mode):| `:q` = Close | `:x` = `:wq` = Save & Close |

```
pacman -S wireless-regdb;
```

```
vim /etc/conf.d/wireless-regdom
```

> Uncomment:

```
  WIRELESS_REGDOM="DE"
```

4.6.3 Enable NetworkManager

```
systemctl enable NetworkManager.service;
```

4.6.4 Allow ssh root login (only for next boots)

Note: When you are able to boot into the Desktop Environment, undo the this.

```
pacman -S openssh;
sed -i 's|#PermitRootLogin|PermitRootLogin yes #|' /etc/ssh/sshd_config;
```

4.7 Swap (also for hibernation)

https://wiki.archlinux.org/title/Swap
https://wiki.archlinux.org/title/Btrfs#Swap_file
https://btrfs.readthedocs.io/en/latest/Swapfile.html
https://man.archlinux.org/man/btrfs.5.en#SWAPFILE_SUPPORT

… to extend the virtual memory beyond the installed physical memory (RAM) or to be able to hibernate.

4.7.1 Create a swapfile (for btrfs) (Here: 32 GiB)

Note – For hibernation: If the swap size is smaller than the RAM size and the RAM is not fully utilized, you still have a chance of hibernating successfully.

```
btrfs filesystem mkswapfile --size 32g --uuid clear /swap/swapfile;
```

4.7.2 Add an entry to /etc/fstab

```
vim /etc/fstab
```

> Append:

```
# /swap/swapfile
/swap/swapfile     none      swap      defaults  0 0
```

4.7.3 Lower swappiness value (for low latency)

… to avoid swapping for better system responsiveness.

```
echo "vm.swappiness = 10" > /etc/sysctl.d/99-swappiness.conf;
```

4.8 Mkinitcpio (for UKI) – ATTENTION!

4.8.1 HOOKS (for dm-crypt, hibernation & fsck)

https://wiki.archlinux.org/title/Mkinitcpio#HOOKS
https://wiki.archlinux.org/title/Fsck

Note – If not using dm-crypt: Don't add `sd-encrypt` or delete `keymap`.

```
vim /etc/mkinitcpio.conf
> HOOKS=(base systemd autodetect microcode modconf kms keyboard keymap sd-vconsole sd-encrypt block filesystems fsck)
```

4.8.2 Enable Unified kernel images (UKI)

https://wiki.archlinux.org/title/Unified_kernel_image#mkinitcpio
https://wiki.archlinux.org/title/Arch_boot_process#Boot_loader

Note: Modify other presets accordingly to installed kernels (*linux*, *linux-lts*, …).

Create primary directory for UKIs:

```
mkdir -p /efi/EFI/Linux;
```

```
vim /etc/mkinitcpio.d/linux-zen.preset
```

> Change:

```
#default_image="/boot/initramfs-linux-zen.img"
default_uki="/efi/EFI/Linux/arch-linux-zen.efi"
default_options="--splash /usr/share/systemd/bootctl/splash-arch.bmp"
```

4.8.2.1 Generate all UKIs

```
mkinitcpio -P
```

4.8.2.2 TMP: Remove all "default_images"

```
rm /boot/initramfs-linux*.img;
```

4.8.3 Install missing firmware (Attention!)

READ: https://wiki.archlinux.org/title/Mkinitcpio#Possibly_missing_firmware_for_module_XXXX

… for your GPU, NIC, BT, NPU, etc. Not every missing firmware is important.

Note: When generating the ***default*** UKI using `# mkinitcpio -P`, you may get the warning:
`==> WARNING: Possibly missing firmware for module: 'module_name'`

> Install the corresponding packages for your modules **& from the meta pkg:** `linux-firmware`

Example:

```
pacman -S linux-firmware-other linux-firmware-amdgpu linux-firmware-intel
```

4.9 Kernel command line (for mkinitcpio)

https://wiki.archlinux.org/title/Unified_kernel_image#mkinitcpio
https://wiki.archlinux.org/title/Kernel_parameters
https://docs.kernel.org/admin-guide/kernel-parameters.html

… with your kernel parameters.

TMP: *<**Output of** **<command>** in vim (normal mode) using* ***:r! <command>***>

Create the drop-in config directory:

```
mkdir /etc/cmdline.d;
```

4.9.1 root.conf (for btrfs, hibernation)

https://uapi-group.org/specifications/specs/discoverable_partitions_specification/

Note – For btrfs: The default subvolume is set with `rootflags`. "**`btrfs subvolume set-default`**" is not used because after each system rollback you would have to re-set the new "@" subvolume.

Note – For hibernation: The parameters "resume" & "resume_offset" are not necessary.

```
vim /etc/cmdline.d/root.conf
>
# Btrfs: GPT partition automount
rootflags=subvol=@

# Hide OEM logo & Reduce boot messages
bgrt_disable quiet loglevel=4
```

4.9.1.1 Regenerate all UKIs

```
mkinitcpio -P
```

4.9.2 OPT: performance.conf

```
vim /etc/cmdline.d/performance.conf
>
```

4.9.2.1 For low latency

https://gitlab.freedesktop.org/pipewire/pipewire/-/wikis/Performance-tuning#kernel
https://wiki.archlinux.org/title/Professional_audio#System_configuration

```
# Low latency
preempt=full threadirqs
```

4.9.2.2 Disable staggered spin-up

https://wiki.archlinux.org/title/Improving_performance/Boot_process#Staggered_spin-up

… otherwise, the ATA interfaces are probed serially **>** Thus slower boot speed.

Verify if SSS is being used > Yes (output)?:

```
dmesg | grep SSS
```

```
# Disable staggered spin-up
libahci.ignore_sss=1
```

4.9.2.3 Disable Active-State Power Management (ASPM)

https://wiki.archlinux.org/title/Power_management#Active_State_Power_Management
https://docs.redhat.com/en/documentation/red_hat_enterprise_linux/7/html/power_management_guide/aspm

Note: This can also be a fix for some instability issues like with the Intel I226-V.

Verify ASPM support:

```
journalctl -b | grep ASPM
```

```
# Disable ASPM to allow PCIe links to operate with maximum performance
pcie_aspm.policy=performance
```

After reboot: Verify whether ASPM is disabled:

```
# lspci -vv | grep 'ASPM.*abled;'
```

4.10 Create UEFI boot entries using efibootmgr

https://wiki.archlinux.org/title/Unified_Extensible_Firmware_Interface#efibootmgr
ALT – Boot manager: https://wiki.archlinux.org/title/Unified_kernel_image#**systemd-boot**

… to boot directly from the UEFI boot manager.

```
pacman -S efibootmgr;
```

Do the following for all installed kernels [*linux*, *linux-lts*, …]:

```
efibootmgr --create --disk /dev/nvme0n1 --part 1 --label "Arch Linux Zen" --
loader EFI/Linux/arch-linux-zen.efi --unicode;
```

4.11 Test the Arch Linux installation

4.11.1 Power off the systemd-nspawn container

```
systemctl poweroff
```

4.11.2 Unmount & Reboot

```
umount -R /mnt
```

> Busy partitions?: Ignore (swap), double-check configs AND/OR use `fuser(1)`.

```
systemctl reboot
```

> UEFI boot entry "*Arch Linux Zen*" should be visible.
Otherwise, it *should* be possible to add an entry manually using the UEFI firmware setup utility.
ALT: Use systemd-boot.

4.11.3 Boot problems?

Open LUKS > Mount root partition > chroot > Mount other partitions > Fix typo/problem:

```
loadkeys de-latin1;
cryptsetup open /dev/nvme0n1p2 root;
mount -o compress=zstd,subvol=@ /dev/mapper/root /mnt;
arch-chroot /mnt
```

> Mount all partitions listed in `/etc/fstab`:

```
mount -a;
Later: mount /dev/nvme0n1p1 /efi;
```

> Fix typo/problem

4.12 Enter crypt_password & Login as *root*

Type `root` & Enter *root_password*. Don't forget to Connect via ssh (as root).

4.13 For next steps

```
mkdir /etc/pacman.d/hooks; pacman -S --needed wget;
```

5 Secure Boot

https://wiki.archlinux.org/title/Unified_Extensible_Firmware_Interface/Secure_Boot#Using_your_own_keys

5.1 Install SB tools

```
pacman -S efitools sbsigntools;
```

5.2 Backing up current SB variables

```
mkdir -p efi-keys/0_vendor_keys; cd efi-keys/0_vendor_keys/;
for var in PK KEK db dbx ; do efi-readvar -v $var -o old_${var}.esl ; done
cd ..;
```

5.3 Creating keys in /root/efi-keys/

https://wiki.archlinux.org/title/Unified_Extensible_Firmware_Interface/Secure_Boot#Manual_process

5.3.1 Create a GUID for owner identification

```
uuidgen --random > GUID.txt;
```

5.3.2 Platform Key (PK)

```
openssl req -newkey rsa:4096 -noenc -keyout PK.key -new -x509 -sha256 -days
3650 -subj "/CN=my Platform Key/" -out PK.crt;
openssl x509 -outform DER -in PK.crt -out PK.cer;
cert-to-efi-sig-list -g "$(< GUID.txt)" PK.crt PK.esl;
sign-efi-sig-list -g "$(< GUID.txt)" -k PK.key -c PK.crt PK PK.esl PK.auth;
```

5.3.3 Sign an empty file to allow removing PK when in "User Mode"

```
sign-efi-sig-list -g "$(< GUID.txt)" -c PK.crt -k PK.key PK /dev/null
noPK.auth;
```

5.3.4 Key Exchange Key (KEK)

```
openssl req -newkey rsa:4096 -noenc -keyout KEK.key -new -x509 -sha256 -days
3650 -subj "/CN=my Key Exchange Key/" -out KEK.crt;
openssl x509 -outform DER -in KEK.crt -out KEK.cer;
cert-to-efi-sig-list -g "$(< GUID.txt)" KEK.crt KEK.esl;
sign-efi-sig-list -g "$(< GUID.txt)" -k PK.key -c PK.crt KEK KEK.esl KEK.auth;
```

5.3.5 Signature Database (db)

```
openssl req -newkey rsa:4096 -noenc -keyout db.key -new -x509 -sha256 -days
3650 -subj "/CN=my Signature Database key/" -out db.crt;
openssl x509 -outform DER -in db.crt -out db.cer;
cert-to-efi-sig-list -g "$(< GUID.txt)" db.crt db.esl;
sign-efi-sig-list -g "$(< GUID.txt)" -k KEK.key -c KEK.crt db db.esl db.auth;
```

5.3.6 Microsoft's certificates

https://wiki.archlinux.org/title/Unified_Extensible_Firmware_Interface/Secure_Boot#Microsoft_Windows
https://learn.microsoft.com/en-us/windows-hardware/manufacture/desktop/windows-secure-boot-key-creation-and-management-guidance

Note: Your device *may* only function properly w/ Microsoft's UEFI CA certificates. You may find a checkbox in your UEFI SB settings to include these MS certs. This would be an indication that you **must** add the following UEFI CA certs. You *may* also need "Microsoft *Option ROM* UEFI CA 2023" or rarely *vendor-specific* certificates. **See:** Determine OpROM signature

> Check firmware keys (KEK & db):

```
sbkeysync --dry-run --verbose
```

5.3.6.1 Add Microsoft's UEFI CA certificates (for UEFI drivers, OpROMs)

5.3.6.1.1 Download certificates

```
wget --user-agent="Mozilla" -O MS_UEFI-2011.crt
https://www.microsoft.com/pkiops/certs/MicCorUEFCA2011_2011-06-27.crt;
wget --user-agent="Mozilla" -O MS_UEFI-2023.crt
https://www.microsoft.com/pkiops/certs/microsoft%20uefi%20ca%202023.crt;
wget --user-agent="Mozilla" -O MS_UEFI-OpROM-2023.crt
https://www.microsoft.com/pkiops/certs/microsoft%20option%20rom%20uefi%20ca%202
023.crt;
```

5.3.6.1.2 Create an EFI Signature List

```
sbsiglist --owner 77fa9abd-0359-4d32-bd60-28f4e78f784b --type x509 --output
MS_UEFI-2011_db.esl MS_UEFI-2011.crt;
sbsiglist --owner 77fa9abd-0359-4d32-bd60-28f4e78f784b --type x509 --output
MS_UEFI-2023_db.esl MS_UEFI-2023.crt;
sbsiglist --owner 77fa9abd-0359-4d32-bd60-28f4e78f784b --type x509 --output
MS_UEFI-OpROM-2023_db.esl MS_UEFI-OpROM-2023.crt;
cat MS_UEFI-2011_db.esl MS_UEFI-2023_db.esl MS_UEFI-OpROM-2023_db.esl >
MS_UEFI_db.esl;
```

5.3.6.1.3 Sign the db.esl with your KEK

```
sign-efi-sig-list -a -g 77fa9abd-0359-4d32-bd60-28f4e78f784b -k KEK.key -c
KEK.crt db MS_UEFI_db.esl add_MS_UEFI_db.auth;
```

5.3.6.2 Add Microsoft Windows's db certificates (for Windows)

5.3.6.2.1 Download certificates

```
wget --user-agent="Mozilla" -O Win_UEFI-2023.crt
https://www.microsoft.com/pkiops/certs/windows%20uefi%20ca%202023.crt;
```

5.3.6.2.2 Create an EFI Signature List

```
sbsiglist --owner 77fa9abd-0359-4d32-bd60-28f4e78f784b --type x509 --output
Win_UEFI-2023_db.esl Win_UEFI-2023.crt;
cat Win_UEFI-2023_db.esl > MS_Win_db.esl;
```

5.3.6.2.3 Sign the db.esl with your KEK

```
sign-efi-sig-list -a -g 77fa9abd-0359-4d32-bd60-28f4e78f784b -k KEK.key -c
KEK.crt db MS_Win_db.esl add_MS_Win_db.auth;
```

5.3.6.3 Add Microsoft Windows's KEK certs (for Windows)

… allowing systems to receive DB and DBX updates.

5.3.6.3.1 Download certificates

```
wget --user-agent="Mozilla" -O Win_KEK-2023.crt
https://www.microsoft.com/pkiops/certs/microsoft%20corporation%20kek%202k%20ca%
202023.crt;
```

5.3.6.3.2 Create an EFI Signature List

```
sbsiglist --owner 77fa9abd-0359-4d32-bd60-28f4e78f784b --type x509 --output
Win_KEK-2023.esl Win_KEK-2023.crt;
cat Win_KEK-2023.esl > MS_Win_KEK.esl;
```

5.3.6.3.3 Sign the KEK.esl with your PK

```
sign-efi-sig-list -a -g 77fa9abd-0359-4d32-bd60-28f4e78f784b -k PK.key -c
PK.crt KEK MS_Win_KEK.esl add_MS_Win_KEK.auth;
```

5.3.7 Change working directory

```
cd
```

5.4 Signing the UKIs (using ukify & systemd-sbsign)

https://wiki.archlinux.org/title/Unified_kernel_image#Signing_the_UKIs_for_Secure_Boot

```
cp /usr/lib/kernel/uki.conf /etc/kernel/;
vim /etc/kernel/uki.conf
```

> Uncomment:

```
[UKI]
SecureBootSigningTool=systemd-sbsign
SecureBootPrivateKey=/root/efi-keys/db.key
SecureBootCertificate=/root/efi-keys/db.crt
SignKernel=true
```

Regenerate the UKIs:

```
mkinitcpio -P;
```

5.5 Putting firmware into "Setup Mode"

5.5.1 Reboot into UEFI firmware setup utility

```
systemctl reboot --firmware-setup
```
OR by hitting [F2] after POST

- **Secure Boot settings:**
  Activate vendor specific settings like "Expert Key Management" or "Custom Mode"

5.5.2 Backup & Clear preloaded Secure Boot certificates

- **OPT: Backup** all preloaded Secure Boot keys to a FAT32 formatted USB stick
- **Clear** all Secure Boot certificates: Clear "ALL" **or** db > KEK > PK
  Note: Secure Boot is now in "Setup Mode"
- **Reboot**

5.6 Enrolling keys using sbkeysync

https://wiki.archlinux.org/title/Unified_Extensible_Firmware_Interface/Secure_Boot#Using_sbkeysync

Note: You may need to reset the UEFI administrator password.

5.6.1 Copy each .auth file into their respective location

```
mkdir -p /etc/secureboot/keys/{db,dbx,KEK,PK};
```

```
cp /root/efi-keys/db.auth /etc/secureboot/keys/db/;
cp /root/efi-keys/KEK.auth /etc/secureboot/keys/KEK/;
cp /root/efi-keys/PK.auth /etc/secureboot/keys/PK/;
```

Microsoft's certificates:

```
cp /root/efi-keys/add_MS_UEFI_db.auth /etc/secureboot/keys/db/;
cp /root/efi-keys/add_MS_Win_db.auth /etc/secureboot/keys/db/;
cp /root/efi-keys/add_MS_Win_KEK.auth /etc/secureboot/keys/KEK/;
```

5.6.2 Verify the changes sbkeysync will make to the UEFI keystore

```
sbkeysync --pk --dry-run --verbose
```

5.6.3 Enroll your keys

```
sbkeysync --verbose
sbkeysync --verbose --pk
```

> Write errors?

```
chattr -i /sys/firmware/efi/efivars/{PK,KEK,db}*
```

> Enroll again

> Write error for PK?

```
efi-updatevar -f /etc/secureboot/keys/PK/PK.auth PK
```

5.7 Completing Secure Boot

- **Reboot into UEFI**
- **Enable Secure Boot** (e.g. enable "Windows UEFI mode")
- **Reboot**
- **After testing: Set UEFI administrator password** to protect the firmware settings when using the UEFI firmware setup utility

5.8 Verify Secure Boot status

```
bootctl status
```

```
> System:
      Firmware: UEFI 2.90 (American Megatrends 5.26)
 Firmware Arch: x64
   Secure Boot: enabled (user)
  TPM2 Support: yes
  Measured UKI: yes
  Boot into FW: supported
```

5.9 FYI: Disable SB by removing the PK using noPK.auth

… if you are encountering problems after enabling SB, and if you can't disable SB using the UEFI firmware Setup Utility.

Note: This will change the SB User Mode to Setup Mode. After that:

- Clear all other keys
- Restore your backup keys
- Disable SB

```
efi-updatevar -f noPK.auth PK
```

5.10 TODO: Trusted Platform Module (TPM2)

https://wiki.archlinux.org/title/Trusted_Platform_Module

Warning: This is experimental, just skip for now!

5.10.1 Info

- NvPCR Support in systemd v259

5.10.2 TPM2 PCR policies (using ukify)

https://wiki.archlinux.org/title/Trusted_Platform_Module#PCR_policies

Info: Secure Boot is not required for functionality, but it is required for meaningful integrity guarantees.

5.10.2.1 Security model

- Secure Boot + TPM2 PIN protects against casual theft
- systemd-pcrlock creates policies that allow access to secrets (like LUKS disk keys) only if TPM PCR values match predicted measurements
- Passphrase & Recovery key always work as fallback
- Hardware or Firmware upgrades won't lock you out
- Compatible with btrfs snapshot rollbacks

5.10.2.2 Generate & Include default PCR keys into UKI

```
ukify genkey \
--pcr-private-key=/etc/systemd/tpm2-pcr-private-key.pem \
--pcr-public-key=/etc/systemd/tpm2-pcr-public-key.pem;
```

```
vim /etc/kernel/uki.conf
> Uncomment:
[PCRSignature:initrd]
PCRPrivateKey=/etc/systemd/tpm2-pcr-private-key.pem
PCRPublicKey=/etc/systemd/tpm2-pcr-public-key.pem
```

```
mkinitcpio -P;
systemctl reboot
```

5.10.2.3 Unlock LUKS2 volume w/ TPM2 PIN

Note: This will fix the error "systemd-cryptsetup: No valid TPM2 token data found."

5.10.2.3.1 Generate & Enroll recovery key w/ QR code

https://wiki.archlinux.org/title/Systemd-cryptenroll#Recovery_key

… as a fallback key w/ high entropy.

```
systemd-cryptenroll --recovery-key /dev/disk/by-label/Arch;
```

> **Save** secret recovery key at a secure location, in e.g. a password manager

5.10.2.3.2 Enroll the TPM2 policies in your LUKS2 volume

Info: systemd-pcrlock handles PCR binding automatically.

```
systemd-cryptenroll --wipe-slot tpm2 --tpm2-device auto --tpm2-with-pin=yes
/dev/disk/by-label/Arch;
```

> Enter current passphrase

> Enter new TPM2 PIN

5.10.2.3.3 Rebuild UKIs

```
mkinitcpio -P;
```

5.10.2.3.4 Unlock the LUKS2 volume

Note: *Initially*, you have 4 attempts to enter the TPM2 PIN, otherwise you can enter the passphrase or the recovery key to decrypt the volume. If your attempts failed, TPM2 may go into dictionary attack lock-out mode with reduced attempt.

```
systemctl reboot
```

> Enter TPM2 PIN instead of the passphrase

5.10.2.4 TODO – OPT: Generate hardened TPM2 access policies

https://man.archlinux.org/man/systemd-pcrlock-make-policy.service.8.en

Info: systemd-pcrlock is used to predict TPM2 PCR measurements produced during the boot process and to generate TPM2 access policies based on those predictions. The generated policies are stored in a TPM2 NV index and can later be referenced by TPM-sealed secrets.

Info: This allows TPM2-sealed secrets to survive firmware updates, Secure Boot changes, etc. It is also used to enforce system integrity.

5.10.2.4.1 Check if your TPM2 supports all functionality for systemd-pcrlock

```
/usr/lib/systemd/systemd-pcrlock is-supported
```

5.10.2.4.2 Locking

Note: Each lock targets a specific aspect of system identity or integrity. You should only enable the locks you understand and actually need.

Binds secrets to the system's machine ID

Prevents disk reuse on cloned systems.

```
/usr/lib/systemd/systemd-pcrlock lock-machine-id;
```

Binds secrets to the disk's GPT layout

Detects partition table tampering.

```
/usr/lib/systemd/systemd-pcrlock lock-gpt;
```

OPT: Binds secrets to the Secure Boot policy (PK/KEK/db/dbx)

Warning: Changes to e.g. dbx can lock you out unless policies are regenerated beforehand.

```
/usr/lib/systemd/systemd-pcrlock lock-secureboot-policy;
```

Generate the composite TPM2 policy

After configuring the desired locks, generate the TPM2 policy. This step synthesizes PCR predictions and stores the resulting TPM2 policy in an NV index.

```
/usr/lib/systemd/systemd-pcrlock make-policy;
```

5.10.2.4.3 Enable services

Enable the core pcrlock service (synthesizes predictions)

```
systemctl enable systemd-pcrlock-secureboot-policy.service;
```

Enable other specific locks you configured

```
systemctl enable systemd-pcrlock-machine-id.service;
```

6 System configuration (cont.)

6.1 Normal user

https://wiki.archlinux.org/title/Users_and_groups#User_management

6.1.1 Add a normal user

Note: The first normal user has the numerical User ID "1000" (**id** -u *username* = 1000).
Therefore, you *can* substitute *username* with $(**id** -un 1000) after user creation.
In this document, *username* will sometimes be substituted with $(**logname**).

```
useradd -m username;          < SUBSTITUTE "username" for this whole document!
```

```
passwd username
> user_password
```

6.1.2 Add more permissions to user

https://wiki.archlinux.org/title/Users_and_groups#Group_list

```
usermod -aG wheel,games,ftp,http,audio username
```

OPT – Print permissions/groups of user:

```
groups username
```

6.1.3 Use "doas" instead of "sudo"

https://wiki.archlinux.org/title/Doas

… as a simpler and safer **sudo** replacement.

6.1.3.1 Installation & Allow members of group wheel "doas" acces

```
pacman -S opendoas;
```

```
vim /etc/doas.conf
>
permit persist setenv
{PATH=/usr/local/bin:/usr/local/sbin:/usr/bin:/usr/sbin} :wheel
```

Warning: The configuration file must end with a newline!

6.1.3.2 Change permissions

```
chown -c root:root /etc/doas.conf;
chmod -c 0400 /etc/doas.conf;
```

6.1.3.3 Check for syntax errors

```
doas -C /etc/doas.conf && echo "config ok" || echo "config error";
```

6.1.4 Allow members of group wheel "sudo" access

Note: Some programs require **sudo** for privilege elevation. Package is installed from `base-devel`.

```
EDITOR=rvim visudo
```

> Uncomment:

```
%wheel ALL=(ALL:ALL) ALL
```

6.1.5 Allow only users of group wheel "su" access

https://wiki.archlinux.org/title/Su#su_and_wheel

```
vim /etc/pam.d/su
vim /etc/pam.d/su-l
```

> Uncomment:

```
auth required pam_wheel.so use_uid
```

6.1.6 Realtime

https://wiki.archlinux.org/title/Realtime_process_management

```
pacman -S realtime-privileges;
usermod -aG realtime username
```

6.2 Pacman configuration

https://wiki.archlinux.org/title/Pacman#Configuration

```
vim /etc/pacman.conf
```

>

6.2.1 Enable Color

> Uncomment:

```
Color
```

6.2.2 OPT: Enable the multilib repository (for Steam)

Note: If you do not use packages that depend on 32-bit packages like `steam`, then do not install any 32-bit packages (`lib32-<name>`) in this guide. Simply do not enable the multilib repository.

> Uncomment:

```
[multilib]
Include = /etc/pacman.d/mirrorlist
```

6.2.3 Upgrade System

```
pacman -Syu
```

6.3 Auto update mirrors – reflector

https://wiki.archlinux.org/title/Reflector#systemd_timer

```
pacman -S reflector;

sed -i 's|# --country|--country Germany #|' /etc/xdg/reflector/reflector.conf;

systemctl enable --now reflector.timer;
```

6.4 Discard unused packages weekly – paccache

https://wiki.archlinux.org/title/Pacman#Cleaning_the_package_cache

```
systemctl enable paccache.timer;
```

6.5 Limit journal size – systemd/Journal

https://wiki.archlinux.org/title/Systemd/Journal#Journal_size_limit

```
sed -i 's|#SystemMaxUse=|SystemMaxUse=200M #|' /etc/systemd/journald.conf;
```

6.6 Define missing environment variables

https://wiki.archlinux.org/title/Environment_variables#Using_pam_env
https://wiki.archlinux.org/title/XDG_Base_Directory

```
vim /etc/security/pam_env.conf
```

> Append:

```
# XDG Base Directories
XDG_CONFIG_HOME DEFAULT=@{HOME}/.config
XDG_CACHE_HOME  DEFAULT=@{HOME}/.cache
XDG_DATA_HOME   DEFAULT=@{HOME}/.local/share
XDG_STATE_HOME  DEFAULT=@{HOME}/.local/state

# Console Text Editor
EDITOR          DEFAULT=vim
```

6.7 Makepkg: Build Optimizations (for AUR pkgs)

READ: https://wiki.archlinux.org/title/Makepkg#Optimization

Info: Current makepkg.conf

6.7.1 Change auth method instead of sudo

```
sed -i 's|#PACMAN_AUTH=()|PACMAN_AUTH=(doas)|' /etc/makepkg.conf;
```

6.7.2 Building optimized binaries

… if you do not intent to share the builded AUR packages.

```
sed -i 's|CFLAGS="-march=x86-64 -mtune=generic|CFLAGS="-march=native|'
/etc/makepkg.conf;
sed -i 's|DEBUG_RUSTFLAGS="-C debuginfo=2"|DEBUG_RUSTFLAGS="-C debuginfo=2 -C
target-cpu=native"|' /etc/makepkg.conf.d/rust.conf;
```

6.7.3 Improving build times

6.7.3.1 Parallel compilation

```
sed -i 's|#MAKEFLAGS="-j2"|MAKEFLAGS="--jobs=$(nproc)"|' /etc/makepkg.conf;
```

6.7.3.2 Disable debug packages and LTO

```
sed -i 's|debug lto|!debug !lto|' /etc/makepkg.conf;
```

6.8 Enable Periodic TRIM (if TRIM is supported)

https://wiki.archlinux.org/title/Btrfs#SSD_TRIM
https://wiki.archlinux.org/title/Solid_state_drive#TRIM

Note: TRIM support is disabled by the device-mapper by default, see **`root`**:

6.8.1 Verify TRIM/discard support

```
lsblk --discard
```

> Non-zero values indicate TRIM support:

```
NAME        DISC-ALN DISC-GRAN DISC-MAX DISC-ZERO
nvme0n1            0        4K       2T         0
├─nvme0n1p1        0        4K       2T         0
└─nvme0n1p2        0        4K       2T         0
  └─root           0        0B       0B         0
```

6.8.2 Enable Periodic TRIM (enable weekly fstrim)

… on *all* mounted filesystems on devices that support the discard operation.

Note: Continuous TRIM (asynchronous discard > mount option: `discard=async`) should be enabled by default by Btrfs if the underlying device is capable of TRIM.

```
systemctl enable fstrim.timer
```

7 Install Backend & DE

```
pacman -S <your packages in this chapter>
```

7.1 Graphics driver

https://wiki.archlinux.org/title/Vulkan
https://wiki.archlinux.org/title/GPGPU
https://wiki.archlinux.org/title/Hardware_video_acceleration

Note: All graphics units from the last ~7 years *should* be supported with the following packages.

7.1.1 Non-Nvidia (AMD, Intel, …)

`mesa` `lib32-mesa`

7.1.2 Intel

https://wiki.archlinux.org/title/Intel_graphics

7.1.2.1 Vulkan

`vulkan-intel` `lib32-vulkan-intel`

7.1.2.2 Hardware video acceleration – Intel Video Processing Library

- **For ≥**Gen11 (Tiger Lake): `vpl-gpu-rt`
- **ELSE For ≥**Gen5 (Broadwell): `intel-media-sdk` (Discontinued)

7.1.2.3 OpenCL

- **For ≥**Gen12 (Alder Lake): `intel-compute-runtime`
- **ELSE:** `opencl-mesa`

7.1.3 AMD

https://wiki.archlinux.org/title/AMDGPU

7.1.3.1 Vulkan

`vulkan-radeon` `lib32-vulkan-radeon`

7.1.3.2 OpenCL (if not supported by ROCm)

`opencl-mesa`

7.1.3.3 ROCm: HIP, OpenCL, … (for Blender, PyTorch, …)

https://rocm.docs.amd.com/en/latest/
https://wiki.archlinux.org/title/GPGPU#ROCm
> Supported GPUs

Note: Disable AMD iGPU in SBIOS to avoid unknown issues (for AMD Radeon GPUs).

7.1.3.3.1 HIP (Heterogeneous-Compute Interface for Portability), HIP RT & OpenCL

https://rocm.docs.amd.com/projects/HIP/en/latest/index.html
https://gpuopen.com/hiprt/

`rocm-hip-runtime` `hiprt` `rocm-opencl-runtime`

After reboot – Verify support:

```
/opt/rocm/bin/clinfo | grep -i "image support"
>> Image support: Yes
```

7.1.3.3.2 AMD System Management Interface library

https://rocm.docs.amd.com/projects/amdsmi/en/latest/index.html
https://rocm.docs.amd.com/projects/amdsmi/en/latest/how-to/amdsmi-cli-tool.html
https://rocm.blogs.amd.com/software-tools-optimization/amd-smi-overview/README.html

"… offers a unified tool for managing and monitoring GPUs, particularly in high-performance computing environments."

`amdsmi`

REQ:

```
usermod -aG render $(logname);
```

Show utilization:

```
amd-smi monitor
```

Show detailed hardware info and settings:

```
amd-smi static
```

Set power profile (for e.g. compute, VR):

```
amd-smi set --profile THREE_D_FULL_SCR_MASK
```

Reset power profile:

```
amd-smi reset --profile
```

7.1.4 NVIDIA

READ: https://wiki.archlinux.org/title/NVIDIA

7.1.4.1 Install the appropriate driver for your card

Identify your GPUs family:

```
lspci -k -d ::03xx
```

For ≥Turing (NV160/TUXXX) – (≥RTX & GTX 16):

- For `linux`: `nvidia-open`
- For `linux-lts`: `nvidia-open-lts`
- For other kernels: `nvidia-open-dkms` `linux-zen-headers`

7.1.4.2 NVIDIA drivers utilities

`nvidia-utils` `lib32-nvidia-utils`

7.1.4.3 VA-API Hardware video acceleration

`libva-nvidia-driver`

7.1.4.4 OpenCL

`opencl-nvidia` `lib32-opencl-nvidia`

7.1.4.5 CUDA & HIP

`cuda` `hip-runtime-nvidia`

7.1.5 VM – QEMU Guest

https://wiki.archlinux.org/title/QEMU#Preparing_an_Arch_Linux_guest

`qemu-guest-agent` `spice-vdagent`

7.1.6 VM – Oracle VirtualBox Guest

https://wiki.archlinux.org/title/VirtualBox/Install_Arch_Linux_as_a_guest

`virtualbox-guest-utils-nox` (Wayland only)

```
> systemctl enable vboxservice.service;
```

7.2 Fonts

https://wiki.archlinux.org/title/Fonts

LibreOffice: `ttf-liberation` `ttf-carlito` (Aptos equivalent is missing)
For KDE (full unicode coverage): `noto-fonts` `noto-fonts-cjk` `noto-fonts-emoji`
HQ, for Firefox, mpv, …: `adobe-source-sans-fonts` `adobe-source-han-sans-otc-fonts` `adobe-source-serif-fonts` `adobe-source-han-serif-otc-fonts`
Monospaced w/ programming ligatures: `ttf-firacode-nerd`

7.3 Multimedia frameworks

7.3.1 ALSA (utilities)

https://wiki.archlinux.org/title/Advanced_Linux_Sound_Architecture

Note: You may need to configure your audio device using **`alsamixer`**. **Tip:** Try to lower your "Mic Boost" to reduce noise. This usually also changes the microphone volume.

`alsa-utils`

7.3.2 Pipewire

https://wiki.archlinux.org/title/PipeWire
https://wiki.archlinux.org/title/WirePlumber

Basic: `lib32-pipewire`
JACK: `pipewire-jack` `lib32-pipewire-jack`
ALSA: `pipewire-alsa`
Camera: `pipewire-libcamera`

Graph-GUI: `qpwgraph` or `helvum`

7.3.3 Qt Multimedia (default) backend

https://doc.qt.io/qt-6/qtmultimedia-index.html

`qt6-multimedia-ffmpeg`

7.3.4 Gstreamer

https://wiki.archlinux.org/title/GStreamer

7.3.4.1 PipeWire & Libcamera integration

`gst-plugin-pipewire` `gst-plugin-libcamera`

7.3.4.2 Hardware video acceleration

Non-Nvidia: `gst-plugin-va`
Nvidia: `gst-plugins-bad`

7.3.4.3 Plugins

`gst-libav` `gst-plugins-good` `gst-plugins-bad` `gst-plugins-ugly`

7.4 WM/DE – KDE Plasma + KDE Gear

https://community.kde.org/Distributions/Packaging_Recommendations
Comparison of Desktop Environments: https://eylenburg.github.io/de_comparison.htm

7.4.1 KDE Plasma

https://wiki.archlinux.org/title/KDE

`plasma-meta`

7.4.2 KDE Gear

https://apps.kde.org **> See:** `kde-applications-meta`

KDE Meta Package	Recommended & Optional apps
`kde-system-meta`	`kde-system-meta`
`kde-utilities-meta`	`ark` `filelight` `isoimagewriter` `kate` `kcalc` `kcharselect` `kclock` `kdialog` `kfind` `konsole` `kwalletmanager` `markdownpart` `qrca` `skanpage` `yakuake`
`kde-graphics-meta`	`colord-kde` `gwenview` `kamera` `kcolorchooser` `kdegraphics-thumbnailers` `okular` `skanlite` `svgpart`
`kde-multimedia-meta`	`ffmpegthumbs` `kdenlive`
`kde-network-meta`	`kdeconnect` `sshfs` `kdenetwork-filesharing` `krdc` `freerdp` `tokodon`
`kde-pim-meta`	`kleopatra` `merkuro`
`kde-sdk-meta`	`dolphin-plugins` `kompare`

7.4.3 OPT: (3rd-party) Packages w/ KDE integration [deps]

- **Power profiles (balanced, power-saver, performance):** `power-profiles-daemon`
  > `systemctl` enable power-profiles-daemon.service;
- **Hybrid/Multi-GPU support:** `switcheroo-control`
- **Automatic screen rotation:** `iio-sensor-proxy`

7.4.4 Image formats (JPEG XL Master Race) [deps]

https://wiki.archlinux.org/title/Dolphin#File_previews

`kimageformats` `qt6-imageformats` `libavif`

7.4.5 Misc. [deps]

- **File archiver (for ark):** `7zip` `unrar`
- **OCR (for spectacle):** `tesseract-data-eng` `tesseract-data-deu`
- **Faster find than `find` (for `kfind`):** `plocate`
  > Later: **`systemctl`** enable plocate-updatedb.timer

7.5 Misc.

https://wiki.archlinux.org/title/Laptop

7.5.1 Hybrid graphics

> https://wiki.archlinux.org/title/Hybrid_graphics
> https://wiki.archlinux.org/title/PRIME

7.5.1.1 NVIDIA PRIME render offload

`nvidia-prime`

7.6 After installation

7.6.1 Change installation reason of opt. dependencies

Note: Search for the tag **[deps]** in this major chapter.

```
pacman -D --asdeps [deps];
```

8 Display Manager – KDE Plasma Login Manager

https://wiki.archlinux.org/title/Plasma_Login_Manager
https://wiki.archlinux.org/title/Display_manager

8.1 Configuration

TODO

8.2 Enable & Reboot into Plasma Login Manager

```
systemctl enable plasmalogin;
systemctl reboot
```

8.3 Congratulations on reaching this point!

… but this guide is not done with you!

Note: From now on, login as user (not as "root"). Open Konsole or Yakuake to execute commands.

8.4 Check whether hibernation is working

… if it has been set up. Note that hibernation usually not work in a VM.

```
systemctl hibernate
```

8.5 TMP: Change theme to "Breeze"

Note: Custom Display Manager themes can cause issues.

Open "System Settings" **> Search:** "Login Screen"**:** Breeze **>** Apply

9 Btrfs snapshots

9.1 Setup snapshots using snapper & snap-pac

https://wiki.archlinux.org/title/Snapper

9.1.1 Open interactive shell with root prompt for this chapter

```
doas -s
```

9.1.2 Installation

```
pacman -S snapper;
```

9.1.3 Configuration of snapper and mount point

https://wiki.archlinux.org/title/Snapper#Configuration_of_snapper_and_mount_point

9.1.3.1 /.snapshots/ must not exist (for snapper create-config /)

```
umount /.snapshots;
rmdir /.snapshots/;
```

9.1.3.2 Create the configuration file for the subvolume mounted at /

```
snapper -c root create-config /;
```

9.1.3.3 Delete the subvolume automatically created by snapper

```
btrfs subvolume delete /.snapshots;
```

OPT – Check:

```
btrfs subvolume list /
```

9.1.3.4 Recreate, Remount & Change permissions of /.snapshots/

```
mkdir /.snapshots;
mount -a;
chmod 750 /.snapshots;
```

9.1.4 Other configurations

9.1.4.1 Lower snapshot limits & Disable timeline snapshots (for snap-pac)

Note: Snap-pac creates pre/post snapshots (with numbers).

```
vim /etc/snapper/configs/root
>
NUMBER_CLEANUP="yes"
...
NUMBER_LIMIT="20"   (Note: For 10 pacman transactions; for number cleanup algorithm)
...
TIMELINE_CREATE="no"
...
TIMELINE_CLEANUP="no"
```

9.1.4.2 Enable systemd/timer for cleanup

```
systemctl enable snapper-cleanup.timer;
```

9.1.4.3 Also snapshot the ESP

Modified: https://wiki.archlinux.org/title/System_backup#Snapshots_and_/boot_partition

```
pacman -S --needed rsync;
```

```
vim /etc/pacman.d/hooks/95-efibackup.hook
>
[Trigger]
Operation = Upgrade
Operation = Install
Operation = Remove
Type = Path
Target = usr/lib/modules/*/vmlinuz

[Action]
Depends = rsync
Description = Backing up /efi ...
When = PostTransaction
Exec = /usr/bin/rsync -a --delete /efi /.efibackup
```

9.1.5 Wrapping pacman transactions in snapshots

https://wesbarnett.github.io/snap-pac/configuration.html

Note: Snapper will create the snapshots when pacman installs, upgrades or removes a package.

```
pacman -S snap-pac;
```

9.1.6 Create pre/post snapshots for the next step

… by installing e.g. nano. After the restoration, nano is no longer installed.

9.2 Restoring / (subvolume @) to its previous snapshot

Note: Restore now to check if it works and later if the system is broken.

9.2.1 Disable Secure Boot & Boot into a live Arch Linux environment

9.2.2 Open LUKS container & Mount the btrfs volume

```
cryptsetup open /dev/nvme0n1p2 root;
mount /dev/mapper/root /mnt
```

9.2.3 Delete the old backup & Backup "broken" root subvolume

Delete the old "broken" backup:

```
btrfs subvolume delete /mnt/@.broken
```

Backup:

```
mv /mnt/@ /mnt/@.broken
```

9.2.4 Find the snapshot number <num> that you want to recover

```
grep -r '<date>' /mnt/@snapshots/*/info.xml
> /mnt/@snapshots/<num>/info.xml:  <date>yyyy-mm-dd hh:mm:ss</date>
```

9.2.5 Create a read-write snapshot of the read-only snapshot

```
btrfs subvolume snapshot /mnt/@snapshots/<num>/snapshot /mnt/@
```

9.2.6 Restore EFI executables from /.efibackup/

Note: Skip if this is your first run.

```
mount /dev/nvme0n1p1 /mnt/@/efi/;
cp -r /mnt/@/.efibackup/efi/EFI/Linux/* /mnt/@/efi/EFI/Linux/;
```

9.2.7 Unmount & Reboot

```
umount -R /mnt;
systemctl reboot
```

9.2.8 Boot problems?

Change root to your restored snapshot in order to regenerate your UKIs.

9.2.9 Fix pacman error: "failed to synchronize all databases"

https://wiki.archlinux.org/title/Pacman#"Failed_to_init_transaction_(unable_to_lock_database)"_error

```
doas rm /var/lib/pacman/db.lck
```

9.2.10 For Secure Boot

Enable Secure Boot & Reboot.

10 Security – Hardening Arch Linux

https://wiki.archlinux.org/title/Security

GOAL: Creation of a secure *and* useful system.

10.1 Open interactive shell with root prompt for this chapter

```
doas -s
```

10.2 Restrict programs' capabilities – AppArmor

https://wiki.archlinux.org/title/Security#Mandatory_access_control
https://wiki.archlinux.org/title/AppArmor

10.2.1 Installation

10.2.1.1 Kernel parameters (for UKI)

```
vim /etc/cmdline.d/security.conf
>
# AppArmor
lsm=landlock,lockdown,yama,integrity,apparmor,bpf
```

Note: Make sure that *apparmor* is the first "major" module in the list.

10.2.1.2 Kernel lockdown (also for Secure Boot)

https://wiki.archlinux.org/title/Security#Kernel_lockdown_mode
kernel_lockdown(7), Protecting Secure Boot

```
vim /etc/cmdline.d/security.conf
>
# Kernel lockdown (disables hibernation)
lockdown=integrity
```

10.2.1.3 Regenerate all UKIs

```
mkinitcpio -P
```

10.2.1.4 Install & Enable AppArmor

```
pacman -S apparmor;
systemctl enable apparmor.service;
```

10.2.2 Speed-up AppArmor start by caching profiles

```
sed -i 's|#write-cache|write-cache|' /etc/apparmor/parser.conf;
```

10.2.3 Reboot

```
systemctl reboot
```

10.2.4 Verify

```
aa-enabled;
aa-status;
```

10.3 Sandboxing applications – Firejail

https://wiki.archlinux.org/title/Security#Sandboxing_applications
https://wiki.archlinux.org/title/Firejail

10.3.1 Installation

```
pacman -S firejail;
```

10.3.2 Load AppArmor profile into the kernel

firejail(1) § APPARMOR

… or just reboot the system.

```
apparmor_parser -r /etc/apparmor.d/firejail-default;
```

10.3.3 Hardening Firejail

https://firejail.wordpress.com/documentation-2/basic-usage/#suid

… to mitigate privilege escalation.

10.3.3.1 Force use of nonewprivs

Note: This *can* break specific applications like VirtualBox.

```
sed -i 's|# force-nonewprivs no|force-nonewprivs yes|'
/etc/firejail/firejail.config;
```

10.3.3.2 Generate config files

```
firecfg;
```

10.3.3.3 Add the user to the user access database

```
firecfg --add-users username;
```

10.3.4 Automatically run firecfg on pacman transactions

```
vim /etc/pacman.d/hooks/firejail.hook
>
[Trigger]
Type = Path
Operation = Install
Operation = Upgrade
Operation = Remove
Target = usr/bin/*
Target = usr/share/applications/*.desktop

[Action]
Description = Configure symlinks in /usr/local/bin based on firecfg.config...
When = PostTransaction
Depends = firejail
Exec = /bin/sh -c 'firecfg >/dev/null 2>&1'
```

10.3.5 Verify if running applications are sandboxed

```
firejail --list
```

> If running <app> **is not sandboxed:**

```
vim ~/.local/share/applications/<app>.desktop
```

> Modify: `Exec=...`

ALT – KDE App Launcher: "Edit Application…"
> Program: steam**, Command-line arguments:** %U

10.3.6 OPT: Configuration

10.3.6.1 Allow (DRM) execution in browsers

```
sed -i 's|# browser-allow-drm no|browser-allow-drm yes|'
/etc/firejail/firejail.config;
```

10.3.6.2 Enable U2F in browsers (for Hardware Security Key)

```
sed -i 's|# browser-disable-u2f yes|browser-disable-u2f no|'
/etc/firejail/firejail.config;
```

10.3.7 Creating firejail overrides (as *user*)

https://github.com/netblue30/firejail/wiki/Creating-overrides

… if an app is not working properly.

10.3.7.1 Create directory

```
mkdir ~/.config/firejail
```

10.3.7.2 Verify if the app is working without firejail

```
firejail --noprofile <app>
```

10.3.7.3 Read the profile of the app for override recipes

Note: Not every recipe is listed in these profiles. Search through the issues of firejail.

```
less /etc/firejail/<app>.profile
```

10.3.7.4 Create the overrides

Note: `globals.local` will affect every regular profile.
Note: You can take a look at my firejail locals, esp. `{firefox,keepassxc,steam}.local`

```
vim ~/.config/firejail/<app>.local
```

10.3.8 Notes

- The `~/Downloads` directory can be considered as a shared directory. So do not store any sensitive files there.
- You can create your own profiles in `~/.config/firejail/<app>.profile`
- NVIDIA users may get more issues

10.3.9 Info: Disable firejail for an app

… if creating the overrides file does not help.

10.3.9.1 Disable app.profile

```
doas vim /etc/firejail/firecfg.config
```

> Comment out: `<app>`

10.3.9.2 Remove all firejail symbolic links

```
doas firecfg --clean;
```

10.3.9.3 Re-enable all system links (w/o app.profile)

```
doas firecfg;
```

10.3.10 Workaround: Spectacle

https://github.com/netblue30/firejail/issues/5127#issuecomment-1545731039

```
sed -i 's|Exec=spectacle|Exec=/usr/bin/spectacle|'
~/.local/share/applications/org.kde.spectacle.desktop;
```

10.4 More Kernel Hardening

https://wiki.archlinux.org/title/Security#Kernel_hardening
https://wiki.archlinux.org/title/Sysctl

10.4.1 Print current value of <parameter>

```
sysctl -a | grep <parameter>
```

10.4.2 BPF hardening

https://wiki.archlinux.org/title/Security#BPF_hardening

Disable BPF of unprivileged code:

```
echo kernel.unprivileged_bpf_disabled=1 >> /etc/sysctl.d/99-sysctl.conf;
```

10.4.3 Reverse path filtering (loose ⇨ strict)

https://wiki.archlinux.org/title/Sysctl#Reverse_path_filtering

… for source validation of the packets received from all the network interfaces.

```
echo net.ipv4.conf.default.rp_filter=1 >> /etc/sysctl.d/99-sysctl.conf;
echo net.ipv4.conf.all.rp_filter=1 >> /etc/sysctl.d/99-sysctl.conf;
```

10.5 Firewall – Firewalld

https://wiki.archlinux.org/title/Firewalld

10.5.1 Install, Enable & Reboot

```
pacman -S firewalld;
systemctl enable firewalld.service;
systemctl reboot
```

10.5.2 Changing zone to "home" of your network interface

… from the default zone "public".

Use GUI `firewall-config` or:

```
firewall-cmd --zone=home --change-interface=<interface>
```

Note: The interface is the same as:

```
ip addr show <interface>
```

10.5.3 Adding services to the zone "home"

Example: KDE Connect

Check available services:

```
firewall-cmd --get-services | grep kde
```

Add service:

```
firewall-cmd --permanent --zone=home --add-service=kdeconnect;
firewall-cmd --reload
```

10.6 Restricting root login

https://wiki.archlinux.org/title/Security#Restricting_root_login

… instead use `doas` or `sudo`.

```
passwd --lock root;
```

10.7 Mount hardening of the ESP

... by using systemd GPT partition automounting w/ more secure mount options.

```
vim /etc/fstab
> Comment out
# /dev/nvme0n1p1
#UUID=...   /efi   vfat
```

10.8 fwupd (Firmware updater & Verify platform security)

https://wiki.archlinux.org/title/Fwupd
Devices supported by LVFS: https://fwupd.org/lvfs/devicelist

`fwupd`

10.8.1 Setup for UEFI upgrade (using own keys & pacman hook)

https://wiki.archlinux.org/title/Fwupd#Using_your_own_keys

```
vim /etc/pacman.d/hooks/sign-fwupd-secureboot.hook
>
[Trigger]
Operation = Install
Operation = Upgrade
Type = Path
Target = usr/lib/fwupd/efi/fwupdx64.efi

[Action]
Description = Signing fwupdx64.efi for SecureBoot...
When = PostTransaction
Exec = /usr/bin/sbsign --key /root/efi-keys/db.key --cert /root/efi-
keys/db.crt /usr/lib/fwupd/efi/fwupdx64.efi
Depends = sbsigntools
```

```
vim /etc/fwupd/fwupd.conf  (See: man 5 fwupd.conf)
>
[uefi_capsule]
DisableShimForSecureBoot=true
```

Trigger pacman hook & Restart service:

```
pacman -S fwupd-efi;
systemctl restart fwupd.service;
```

10.8.2 Update firmware & UEFI dbx

Note – for KDE & Gnome: Use the GUI, or:

```
fwupdmgr get-updates
```

10.8.3 UEFI Firmware Hardening – Host Security ID (HSI)

https://fwupd.github.io/libfwupdplugin/hsi.html
User Host Security Reports: https://fwupd.org/lvfs/hsireports/devices

GOAL: HSI:3 (Protected State)

Note: You may have to contact your motherboard or system manufacturer to verify the platform security, **see:** "Supported CPU".

10.8.3.1 Verify Host Firmware Security

```
fwupdmgr security
```

10.8.3.2 UEFI Settings

TODO:

For HSI-2:

- **SPI Write Protection** prevents unauthorized modifications to the UEFI firmware stored in the Serial Peripheral Interface (SPI) flash memory
- **IOMMU** (AMD-Vi, Intel VT-d) to mitigate against DMA attacks

For HSI-3:

- **Pre-boot DMA Protection** and **Kernel DMA Protection Indicator**
- **Suspend-to-idle**

Misc. (should be already enabled):

- **AMD Variable Protection** protects some AMD specific runtime variables for CBS, PBS and AOD protected by the UEFI Administrator passphrase
- **NX Mode (No-Execute)** blocks code execution in certain regions of memory that are not supposed to execute code, such as the stack and heap
- **SVM** and **SVM Lock** (Secure Virtual Machine) (AMD-V, Intel VT-x)

10.9 Network Security

10.9.1 DNS

Info: For simplicity reasons, systemd-resolved will be used.

10.9.1.1 DNS caching and conditional forwarding (for NetworkManager)

https://wiki.archlinux.org/title/NetworkManager#DNS_caching_and_conditional_forwarding

"The advantages of this setup is that DNS lookups will be cached, shortening resolve times, and DNS lookups of VPN hosts will be routed to the relevant VPN's DNS servers."

> So all you need to do is enable e.g. systemd-resolved as described **in the next step**.

10.9.1.2 Enable systemd-resolved

https://wiki.archlinux.org/title/Systemd-resolved#DNS

Info: Multicast DNS (mDNS) will be automatically enabled too. Therefore, Avahi should not be used. Firewalld should have the mDNS service enabled by default.

```
systemctl enable --now systemd-resolved.service;
ln -sf ../run/systemd/resolve/stub-resolv.conf /etc/resolv.conf;
```

10.9.1.3 DNS over TLS

Info: DNS over QUIC (DoQ) is currently not supported, see #23770.
Test DoT: https://www.cloudflare.com/ssl/encrypted-sni/
> Implement: https://wiki.archlinux.org/title/Systemd-resolved#DNS_over_TLS

10.9.1.4 DNSSEC

https://wiki.archlinux.org/title/DNSSEC
Info & Test: https://wander.science/projects/dns/dnssec-resolver-test/

… if your router does not handle DNSSEC validation.

10.9.1.4.1 Verify DNSSEC validation on the router side (Here: 192.168.1.1)

`ldns`

```
# Should return: NOERROR /w "ad" flag
drill -D test.dnscheck.tools @192.168.1.1

# Should return: SERVFAIL
drill -D badsig.test.dnscheck.tools @192.168.1.1
```

10.9.1.4.2 OPT: Enable DNSSEC (that may cause problems)

> https://wiki.archlinux.org/title/Systemd-resolved#DNSSEC

```
mkdir /etc/systemd/resolved.conf.d/;
vim /etc/systemd/resolved.conf.d/dnssec.conf
>
[Resolve]
DNSSEC=true
```

10.10 Harden yourself

> https://wiki.archlinux.org/title/Security
> Useful applications: https://wiki.archlinux.org/title/List_of_applications/Security

11 Software specific

https://wiki.archlinux.org/title/List_of_applications

Note: You can take a look at my configuration files.

11.1 Copy config files (Here: using sftp)

… or simply use a USB drive.

Connect:

```
sftp username@<ip addr>
For VirtualBox: sftp -P 3022 username@localhost
```

Change working directory:

```
cd Downloads/;
```

Copy your local configuration files to the new system:

```
put -r /home/local_username/path/to/config/
```

11.2 Zsh

https://wiki.archlinux.org/title/Zsh

11.2.1 Install & Change shell (for user & root)

```
doas pacman -S --needed zsh zsh-completions;
```

```
chsh -s /usr/bin/zsh;
doas chsh -s /usr/bin/zsh;
```

11.2.2 Interactive shell configuration

Note: You can take a look at my configuration files. However, you should first install the packages contained in `zsh.txt`.

ALT: Generate a basic config file in zsh itself by following the initial steps.

- `/etc/zsh/zshrc`

11.2.3 Theme: Starship (w/ nerd font)

https://starship.rs/

Note: Also compatible with other OSs and shells such as Bash or PowerShell.

```
doas pacman -S --needed starship ttf-firacode-nerd;
```

11.2.3.1 Configure your shell to initialize starship

```
doas vim /etc/zsh/zshrc
```

> Append:

```
eval "$(starship init zsh)"
```

11.2.3.2 Set an initial preset

https://starship.rs/presets/

… as a base to configure further to your liking.

```
starship preset <preset> -o ~/.config/starship.toml
```

11.2.4 Configuring Zsh $PATH

https://wiki.archlinux.org/title/Zsh#Configuring_$PATH

Path	Info
`~/.local/bin`	**User-specific** executable files (recommended by XDG)
`~/.cargo/bin`	**Rust** binary crates (using `cargo install`)
`/opt/rocm/bin`	**AMD ROCm** executables (if installed earlier)

```
vim ~/.zshenv
```
>
```
typeset -U path PATH
path=(~/.local/bin ~/.cargo/bin /opt/rocm/bin $path)
export PATH
```

```
source ~/.zshenv;
```

11.3 AUR helper & Pacman wrapper – paru

https://wiki.archlinux.org/title/AUR_helpers#Pacman_wrappers
https://github.com/morganamilo/paru

11.3.1 Install paru + opt. dependencies

```
doas pacman -S --needed --asdeps rust devtools bat;
```

```
git clone https://aur.archlinux.org/paru.git;
cd paru; makepkg -si
```

```
cd ..; rm -rf paru/;
```

11.3.2 Configuration: Use doas instead of sudo

See: `man paru.conf`

```
mkdir ~/.config/paru;
wget -P ~/.config/paru/
https://raw.githubusercontent.com/Morganamilo/paru/master/paru.conf;
```

```
vim ~/.config/paru/paru.conf
```
> Uncomment:
```
  [bin]
  Sudo = doas
```

11.3.3 Important commands (pacman wrapper)

```
System Upgrade:     $ paru              := # pacman -Syu
                    $ paru -Sua         := Upgrade only AUR packages

Install <pkg>:      $ paru -S <pkg>     := # pacman -S <pkg>
                    $ paru "<pkg>"      := Search & Install "<pkg>"
```

11.3.4 Skip certain (AUR) packages from being upgraded

READ: https://wiki.archlinux.org/title/Pacman#Skip_package_from_being_upgraded

```
doas vim /etc/pacman.conf
> IgnorePkg   = <pkg1> <pkg2> ... <pkgN>
```

11.4 Install your packages from text files (using zsh)

```
doas pacman -S --needed - < *.txt
paru -S --needed - < AUR/*.txt
```

11.5 Firefox

https://wiki.archlinux.org/title/Firefox

`firefox` `firefox-i18n-en-us` `firefox-i18n-de`

11.5.1 Firefox profile on RAM (using profile-sync-daemon)

https://wiki.archlinux.org/title/Profile-sync-daemon
https://wiki.archlinux.org/title/Firefox/Profile_on_RAM

`profile-sync-daemon`

11.5.1.1 Relocate cache to RAM only (disable disk cache)

If not using Arkenfox user.js:
> Type in address bar of Firefox (Ctrl+L): `about:config`
> `browser.cache.disk.enable = false`

11.5.1.2 Create configuration file

```
psd
```

11.5.1.3 Edit configuration file

```
sed -i 's|#BROWSERS=()|BROWSERS=(firefox)|' ~/.config/psd/psd.conf;
```

11.5.1.4 Enable user service

```
systemctl enable --now --user psd.service;
```

11.5.2 Setup Firefox (using arkenfox user.js & uBlock Origin)

11.5.2.1 Goals

- Privacy & enhanced security
- Reduction of tracking & fingerprinting
- Side effects: Faster page load; Better battery, memory & network bandwidth usage
- Quality of Life

11.5.2.2 Arkenfox user.js (hardened config template)

> https://github.com/arkenfox/user.js/wiki

11.5.2.2.1 Create a new profile

Enter in address bar of Firefox: `about:profiles`
> Click on "Create a New Profile"

11.5.2.2.2 Change to "Root Directory"

```
cd ~/.mozilla/firefox/XXX.profileName;
```

11.5.2.2.3 Download the update scripts & make them executable

```
wget https://raw.githubusercontent.com/arkenfox/user.js/master/prefsCleaner.sh
https://raw.githubusercontent.com/arkenfox/user.js/master/updater.sh;
```

```
chmod +x ./updater.sh ./prefsCleaner.sh;
```

11.5.2.2.4 Create the user-overrides.js (for updater)

https://github.com/arkenfox/user.js/wiki/3.1-Overrides
https://github.com/arkenfox/user.js/wiki/3.2-Overrides-[Common]

… which will change or add settings to the `user.js`.

Note: You can take a look at my `user-overrides.js` (also with some QoL settings).

11.5.2.2.5 Update user.js (~every quarter)

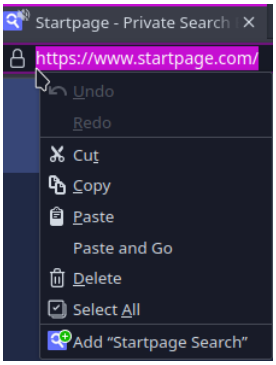
https://github.com/arkenfox/user.js/wiki/3.4-Apply-&-Update-&-Maintain
https://github.com/arkenfox/user.js/wiki/3.5-prefsCleaner

Note: Make sure Firefox is closed.

```
./updater.sh; ./prefsCleaner.sh
```

11.5.2.3 Search engines

In address bar: `about:preferences#search`
> Delete *Search Shortcuts*: Google, Bing, …



> Add a privacy-friendly search engine (⇨)

- https://www.**startpage**.com (uses Google search)
- https://**searx**.space (**>** choose a SearXNG instance)
- https://www.**qwant**.com (uses also Bing search)
- https://**duckduckgo**.com (USA, but has good keyboard navigation)

11.5.2.4 Extensions

11.5.2.4.1 Basic

https://github.com/arkenfox/user.js/wiki/4.1-Extensions

- **uBlock Origin** – https://addons.mozilla.org/firefox/addon/ublock-origin/
- **Skip Redirect** – https://addons.mozilla.org/firefox/addon/skip-redirect/
  Note: Deactivate for e.g. Wi-Fi hotspot logins

11.5.2.4.2 Extras

- **KDE Plasma Integration** – https://addons.mozilla.org/firefox/addon/plasma-integration/
- **KeePassXC-Browser** – https://addons.mozilla.org/firefox/addon/keepassxc-browser/
  Integration of the password manager KeePassXC
  > In KeePassXC: Enable browser integration for Firefox
- **OPT: LibRedirect** – https://addons.mozilla.org/firefox/addon/libredirect/
  Redirects YouTube, Twitter, Instagram, … to privacy-friendly frontends & backends
- **OPT: Violentmonkey** – https://addons.mozilla.org/firefox/addon/violentmonkey/
  User Script manager
- **OPT: Binnen-I be gone** – https://addons.mozilla.org/de/firefox/addon/binnen-i-be-gone/
  For Germans: Filtert Binnen-Is

11.5.2.5 uBlock Origin: Hard mode (aka. block 3rd-party)

https://github.com/gorhill/uBlock/wiki/Blocking-mode **>** Hard mode
https://github.com/gorhill/uBlock/wiki/Quick-guide:-popup-user-interface

11.5.2.5.1 Enable hard mode

***Settings* pane:**

- *I am an advanced user*: checked

***Filter lists* pane:**

- All of uBO's custom filter lists: checked
- *EasyList*: checked
- *Peter Lowe's Ad server list*: checked
- *EasyPrivacy*: checked
- *Online Malicious URL Blocklist*: checked
- *Import …*: Paste link of Actually Legitimate URL Shortener Tool
- **> "Apply Changes"**

***My rules* pane – Add:**

```
* * 3p block
* * 3p-script block
* * 3p-frame block
```

11.5.2.5.2 OPT: Add global whitelist rules for all sites

***My rules* pane – Example:**

```
* akamai.net * noop
* akamaiedge.net * noop
* akamaihd.net * noop
* cloudflare.com * noop
* cloudflare.net * noop
* cloudfront.net * noop
* documentfoundation.org * noop
* fastly.net * noop
* freedesktop.org * noop
* github.io * noop
* githubusercontent.com * noop
* hwcdn.net * noop
* imgur.com * noop
* jquery.com * noop
* jsdelivr.net * noop
* kde.org * noop
* openstreetmap.org * noop
* shopify.com * noop
* sstatic.net * noop
* wikimedia.org * noop
* wordpress.com * noop
* wp.com * noop
```

11.5.2.6 OPT – Theme: Line over tab (like in Photon – FF88)

> Copy my `chrome/` directory into your profile directory **>** Change line color (`#e84d0e`)

Note: Style generated from https://www.userchrome.org/firefox-89-styling-proton-ui.html#tabstyler

11.5.3 Tor Browser

https://gitlab.torproject.org/tpo/applications/torbrowser-launcher

```
flatpak install flathub org.torproject.torbrowser-launcher -y
```

Config dir: Visit "`about:profiles`" **>** "Root Directory" **>** …`/TorBrowser/Data/`

11.6 LibreOffice

https://wiki.archlinux.org/title/LibreOffice
https://help.libreoffice.org

- `libreoffice-still` (Stable maintenance branch) OR
- `libreoffice-fresh` (Feature branch)

11.6.1 OPT: Language pack only for localized user interface

- `libreoffice-still-de` OR
- `libreoffice-fresh-de`

11.6.2 Language aids

- **Spell checking:** `hunspell` `hunspell-en_us` `hunspell-de`
- **Hyphenation rules:** `hyphen` `hyphen-de`
- **Thesaurus:** `libmythes` `mythes-en` `mythes-de`
- **Grammar checking:** `languagetool`
  - `systemctl enable languagetool.service;`
  - LO Options **> Languages & Locales:**
    - **LanguageTool Server:** Enable & Base URL: `http://localhost:8081/v2`
    - **Writing Aids:** Enable LanguageTool

11.6.3 Configuration

Delete or Backup old config (also if encountering upgrade issues):

```
rm -rf ~/.config/libreoffice/
```

11.6.3.1 Options

LibreOffice **>** Tools **> Options:**

- **LO > Appearance > New:** "*eye-friendly*"
  - **Document Backgound:** Light Gray 3
  - **Writer Index and table shadings:** Light Gray 2
- **LO *app* > Basic Fonts (Western):** Liberation Sans, 11 pt
  ... if you do not intend to print your works frequently.
- **LO *app* > Grid > Check** "Snap to Grid"

11.6.3.2 View

LibreOffice **> View:**

- **Uncheck** "Field Shadings" [Ctrl+F8]
  Note: This would e.g. creates confusing light gray brackets around copied text.

11.7 Low latency

https://wiki.archlinux.org/title/Gaming#Improving_performance
https://wiki.archlinux.org/title/Professional_audio
https://github.com/CachyOS/CachyOS-Settings

Note: Only if you require a setup with lower latency and greater stability, start considering optimizations!

11.7.1 Reduce output latency

Note: Setting these options may cause tearing and short-lived artifacts to appear.

11.7.1.1 Disable synchronization to vblank (Disable VSYNC)

https://wiki.archlinux.org/title/Gaming#Reducing_DRI_latency
https://dri.freedesktop.org/wiki/ConfigurationOptions/
Intel: https://wiki.archlinux.org/title/Intel_graphics#Disable_Vertical_Synchronization_(VSYNC)

```
vim $HOME/.drirc
>
<driconf>
        <device>
                <application name="Default">
                        <option name="vblank_mode" value="0" />
                </application>
        </device>
</driconf>
```

11.7.1.2 For KDE Plasma: Disable tear prevention

https://invent.kde.org/plasma/kwin/-/wikis/Environment-Variables

```
doas vim /etc/environment
```
> Append:
```
KWIN_DRM_DISABLE_TRIPLE_BUFFERING=1
```

11.7.2 Realtime IRQ thread system tuning

… ensures hardware interrupts get priority.

REQ: preempt_rt/threadirqs enabled kernel. Ensure that the kernel parameters are set.

`rtirq`

```
doas systemctl enable --now rtirq;
```

11.7.3 Gamemode

https://wiki.archlinux.org/title/Gamemode

`gamemode` `lib32-gamemode`

11.7.3.1 Join "gamemode" group to allow renicing

```
doas usermod -aG gamemode $(logname);
```

11.7.3.2 Configuration

```
wget -P ~/.config/
https://raw.githubusercontent.com/FeralInteractive/gamemode/master/example/
gamemode.ini;
```

```
vim ~/.config/gamemode.ini
> renice=10
```

11.7.3.3 Verify

Test config: `gamemoded -t;`
Start: `gamemoderun <app>;`
Verify: `gamemoded -s`

11.7.3.4 Notes

Firejail workaround:

```
firejail --ignore=noroot gamemoderun <app>
```

11.7.4 Verify mouse polling rate

https://wiki.archlinux.org/title/Mouse_polling_rate

```
doas libinput debug-events
```

> Here: 1 kHz

```
eventX   POINTER_MOTION   …   +0.500s
eventX   POINTER_MOTION   …   +0.501s
eventX   POINTER_MOTION   …   +0.502s
```

11.8 PipeWire

https://gitlab.freedesktop.org/pipewire/pipewire/-/wikis
https://pipewire.pages.freedesktop.org/wireplumber/

11.8.1 Performance tuning

https://gitlab.freedesktop.org/pipewire/pipewire/-/wikis/Performance-tuning#rlimits

```
doas vim /etc/security/limits.d/95-pipewire.conf
>
# Default limits for users of pipewire
@pipewire - rtprio 95
@pipewire - nice -19
@pipewire - memlock 4194304
```

```
doas groupadd -r pipewire;
doas usermod -aG pipewire $(logname);
```

11.8.2 Create directories to copy sections of a config file

```
mkdir -p ~/.config/pipewire/{pipewire{,-pulse},jack,client{,-rt}}.conf.d;
```

Note: The default config files are located in `/usr/share/{pipewire,wireplumber}/`

11.8.3 OPT: Increase resampler quality

https://docs.pipewire.org/page_man_pipewire-props_7.html#props__audio_adapter_properties

Note: "Increasing the quality will result in better cutoff and less aliasing at the expense of (much) more CPU consumption, latency and more ringing."

```
vim ~/.config/pipewire/client.conf.d/resample-quality.conf
vim ~/.config/pipewire/pipewire-pulse.conf.d/resample-quality.conf
>
stream.properties = {
    resample.quality      = 10
}
```

11.8.4 Auto change sample rate

https://gitlab.freedesktop.org/pipewire/pipewire/-/wikis/Guide-Rates
https://gitlab.freedesktop.org/pipewire/pipewire/-/wikis/Config-PipeWire#setting-sample-rates

… to avoid up- & downsampling. 48 kHz should still be the default sample rate.

Note: This *may* cause minor problems.

11.8.4.1 Get sample rates supported by your audio device

Note: The sample rates 44.1, 48 & 96 kHz should always be supported.

```
cat /proc/asound/card*/stream0
```

> E.g. Rates: 32000, 44100, 48000, 88200, 96000, 176400, 192000, 352800, 384000

11.8.4.2 Commit changes

```
vim ~/.config/pipewire/pipewire.conf.d/10-rates.conf
>
context.properties = {
    default.clock.allowed-rates = [ 44100 48000 88200 96000 176400 192000 352800
384000 ]
}
```

11.8.5 Reduce default latency: Decrease quantum (buffer size)

… if the client does not specify a quantum.

11.8.5.1 Infos

```
latency = quantum / sampleRate
default_latency = default_quantum / default_sampleRate = 1024 / 48 kHz = 21.3 ms
```

Note: When the graph is using the `96000` samplerate (`default_sampleRate * 2`), the quantum values are scaled (`default_quantum * 2 = 2048 ≤ quantum-limit`).

11.8.5.2 Get a suitable quantum for your audio device

Temporarily force the graph to operate at a lower fixed buffer size until cracking noises occur:

```
pw-metadata -n settings 0 clock.force-quantum <quantum>
```

> E.g. new `default_quantum = 64`
> `default_latency = 64 / 48 kHz = 1.3 ms`

Note: In order for the setting to be adopted, you may pause the audio stream for a short time.

Note: When `sampleRate = 44100 Hz < default_sampleRate`

⇨ `quantum = default_quantum / 2`
⇨ `latency ≈ default_latency / 2`

So at `32/44100` you should not hear any disturbing noises.

ALT – Set: `default.clock.min-quantum = 64` `(= default.clock.quantum)`

11.8.5.3 Change property for the DSP config

```
vim ~/.config/pipewire/pipewire.conf.d/10-quantum.conf
>
context.properties = {
    default.clock.quantum       = 64
}
```

11.8.6 Verify your changes

Monitoring:

```
pw-top
```

ALSA status:

```
cat /proc/asound/card*/pcm*p/sub*/hw_params
```

11.9 Monitoring system performance – MangoHud

https://wiki.archlinux.org/title/MangoHud
https://github.com/flightlessmango/MangoHud

`mangohud` `lib32-mangohud`

11.9.1 Configuration (example)

```
cp /usr/share/doc/mangohud/MangoHud.conf.example
~/.config/MangoHud/MangoHud.conf;
```

```
vim ~/.config/MangoHud/MangoHud.conf
```

> Uncomment:

11.9.1.1 VISUAL

```
# GPU
gpu_temp
gpu_core_clock
gpu_mem_clock
gpu_power
gpu_text=<gpu_name>
gpu_load_change

# CPU
cpu_temp
cpu_power
cpu_text=<cpu_name>
cpu_mhz
cpu_load_change

core_load
core_load_change

# RAM
vram
ram

# Misc (also for screenshots)
engine_version
gpu_name
vulkan_driver
wine

histogram
gamemode
```

11.9.1.2 FYI: INTERACTION

```
# toggle_hud=Shift_R+F12
# toggle_logging=Shift_L+F2
```

11.9.1.3 LOG

```
output_folder=~/Games/mangologs
mkdir -p ~/Games/mangologs
```

11.9.2 Test configuration

```
mangohud glxgears
mangohud vkcube
```

11.9.3 Notes

- **For some OpenGL apps:** `mangohud --dlsym <app>`
- **Use with Gamemode:** `mangohud gamemoderun <app>`

11.10 Gaming

11.10.1 Steam

https://wiki.archlinux.org/title/Steam

`steam`

11.10.1.1 Compatibility tools (Proton)

Info: Proton is a tool which allows you to run Windows games on Linux.

11.10.1.1.1 Update default compatibility tool (yearly)

Info: Use the latest stable Proton version unless there are problems or desired features.

Steam **>** Settings **>** Compatibility **>** Default compatibility tool: <latest stable Proton version>

11.10.1.1.2 Other notable compatibility tools

… which may fix problems or add features.

- Proton Experimental may solve problems in newer games or games w/ 3rd-party launchers
- Proton-CachyOS adds features & is based on Proton Experimental
- dwproton adds extra fixes for anime games & is based on Proton-CachyOS

> Install a compatibility tools manager like ProtonPlus
… to install "Proton-CachyOS Latest" & "DW-Proton Latest" for Steam, Lutris, Bottles, etc.

11.10.1.2 Set launch options for games

… for GameMode & workarounds. **Check game compatibility:** https://www.protondb.com/

Game Properties **>** General: Launch Options

Recommendation – Start w/ GameMode:

```
gamemoderun %command%
```

11.10.1.3 Workaround: Game does not support the controller

- Change the **game-specific** controller layout to e.g. Templates::**Gamepad**
- **ALT:** Change the **"Desktop Layout"** to Templates::**Gamepad**
  This is also very useful for gaming outside of Steam (e.g. using Lutris). Steam must be running.

11.10.1.4 Workaround: Steam is not starting after system upgrade

- Opt in to the Steam Beta
- Use the flatpak version or `steam-native-runtime`

11.10.2 Ubisoft Connect: Connection fix

https://wiki.archlinux.org/title/Sysctl#Enable_MTU_probing

Enable MTU probing:

```
doas vim /etc/sysctl.d/99-sysctl.conf
> net.ipv4.tcp_mtu_probing = 1
```

11.10.3 DualSense Controller (PS5)

https://wiki.archlinux.org/title/Gamepad#PlayStation_4/5_controller

… which is supported by the official Sony Linux driver. You may want to update the firmware.

11.10.3.1 Disable touchpad acting as mouse

… to avoid ghost inputs from the touchpad & to use the touchpad as a button in games.

```
doas vim /etc/udev/rules.d/72-dualsense-disable-touchpad.rules
>
# Disable DualSense controller touchpad acting as mouse
# USB
ATTRS{name}=="Sony Interactive Entertainment DualSense Wireless Controller
Touchpad", ENV{LIBINPUT_IGNORE_DEVICE}="1"
# Bluetooth
ATTRS{name}=="DualSense Wireless Controller Touchpad",
ENV{LIBINPUT_IGNORE_DEVICE}="1"
```

11.11 KDE Configuration

11.11.1 System Settings

11.11.1.1 Input & Output

- **Mouse > Pointer acceleration:** "None"
- **Keyboard > Keyboard model:** "Generic 105-key PC" (for ISO-DE) **| Delay:** "250 ms"
- **Sound > Profile:** Pro Audio, Analog Stereo, Digital Stereo (IEC958)

11.11.1.2 Appearance & Style

- **Colors & Themes > You may only want to change:** Colors, Window Decoration, Icons, Cursors
- **Text & Fonts > Fixed width:** "Fira Code 10pt"

11.11.1.3 Apps & Windows

- **Default Applications:** Set your default apps
- **Window Management >** Window Behavior **> Titlebar Actions >**
  - **Mouse wheel:** "Maximize/Restore"
  - **Middle click:** "Close" (Tab behavior)
- **Window Management >** Window Behavior **> Window Actions >**
  - **Meta + Mouse wheel:** "Move to previous/next desktop"
- **Window Management > Desktop Effects > Disable** "Present Windows" **&** "Tiling Editor"
- **Window Management > Window Rules:**
  - **Create Application settings:** Open app **>** Alt+F3 **> Configure Special Application settings:**
  - **Workaround for Wayland > Add** "Position": Apply Initially
  - **Workaround for some games > Add** "Fullscreen": Force

11.11.1.4 Workspace

- **General Behavior >**
  - **Animation Speed:** "Instant"
  - **Clicking files or folders:** "Opens them" (Clicking next to a file already selects it)
- **Search > File Search > Disable** "File indexing" (If you don't need it)
- **Search > Plasma Search > Disable** "Bookmarks, Browser*, Recent Files, Software*, Web*"

11.11.1.5 Language & Time

- **Spell Check > Set** (Default) Languages **& Check** "Automatic spell checking"

11.11.1.6 System

- **Session >** Background Services **> Disable unneeded services like:** Bluetooth, Plasma Browser Integration Installation Reminder, SMB Watcher, Thunderbolt Device Monitor

11.11.2 Default Panel ("Icons-only Task Manager")

Tip: Open/Switch to an app using Meta+[1..9]. Switch between app windows using (Shift+)Alt+Tab.

- **Enter Edit Mode >**
  - **Position:** Left (to save space). Left and Top are typical navigation areas.
  - **Uncheck** "Floating"
  - **Panel Width:** ≥68 (to be able to display two tray icons in a row)
- **Configure Icons-only Task Manager > Spacing between icons:** "Small"
- **Configure Digital Clock >**
  - **Appearance > Date format:** "Custom" (ddd d = Weekday Day)
  - **Calendar > Check** "Show week numbers", "Holidays" **& Set** Holiday region

11.11.3 Yakuake (top-down terminal)

Tip: If an application also uses F12 as a key binding, press Shift+F12 to avoid opening Yakuake.

- **Autostart Yakuake:** "Autostart" settings **> Add Application:** Yakuake
- **Configure Yakuake >** Behavior: **Uncheck** "Keep window open…" & "Show system tray icon"
- **Manage Profiles > New ("Profile 1"):**
  - **Appearance > Font:** Fira Code Nerd Font Mono 13pt
  - **TODO: Appearance > Complex Text Layout > Check** "Word mode"
    … to enable font ligatures but currently has cursor position issues
  - **General >** Semantic Integration **> Check** "Mouse click in input line moves cursor"
  - **Set new Profile as Default.** Also set this new profile as the default in Konsole.

11.11.4 Dolphin

- **Configure Dolphin > Split View > Check** "Switch between panes with Tab key"
- **Tip: Open an "Admin tab":** Type "`admin:`" in the address bar

11.11.5 Spectacle

- **Image Saving >**
  - **Compression Quality:** 99%
  - **Filename:** `<yyyy>-<MM>-<dd>_` JXL

11.12 Virtualization

https://wiki.archlinux.org/title/Category:Virtualization

GOAL: Set up KVM/QEMU **>** libvirt **>** Virt-Manager for default configuration.
Therefore, libvirt will be running on a *system*-level with default NAT/DHCP networking.

Note: Insert kernel parameters into e.g. `/etc/cmdline.d/virtualization.conf`

11.12.1 UEFI settings

11.12.1.1 Basic

	AMD	Intel
Virtualization	AMD-V or SVM	VT-x
IOMMU	AMD-Vi	VT-d **> Add kernel parameter:** `intel_iommu=on`
	> Add kernel parameter: `iommu=pt` …to disable unsupported devices.	

11.12.1.2 AMD only

https://developer.amd.com/sev/

Setting	Note
SEV – Secure Encrypted Virtualization	
SEV - Secure Nested Paging (3rd gen)	Should only be supported by Ryzen Pro, Threadripper Pro & EPYC CPUs. https://libvirt.org/kbase/launch_security_sev.html
SEV - Encrypted State (2nd gen)	
SEV (1st gen)	
SME – Secure Memory Encryption	
SME	Disabled by default since Linux 5.15. Set kernel parameter `mem_encrypt=on`, but problems can occur!
Transparent SME (aka. Memory Guard)	For physical protection. Other memory encryption features (like SEV) are then disabled. Use as a fallback option.

11.12.1.3 Intel only

See: Intel® Virtualization Technology (Intel® VT)

Setting	Note
TDX – Trust Domain Extensions	≥Xeon family: "Sapphire Rapids"
SGX2, SGX – Software Guard Extensions	Even some consumer CPUs are supported.

11.12.2 KVM (Kernel-based Virtual Machine)

https://wiki.archlinux.org/title/KVM

Note: "KVM is a hypervisor built into the Linux kernel. Unlike native QEMU, which uses emulation, KVM is a special operating mode of QEMU that uses CPU extensions (HVM) for virtualization via a kernel module."

11.12.2.1 Check hardware support

```
LC_ALL=C.UTF-8 lscpu | grep Virtualization
```
> Output: `AMD-V or VT-x`

11.12.2.2 Check if the necessary modules are available in the kernel

```
zgrep CONFIG_KVM /proc/config.gz
```
> Output: `CONFIG_KVM AND (CONFIG_KVM_AMD, _INTEL) is set to "y" or "m"`

11.12.2.3 Check if the kernel modules are automatically loaded

```
lsmod | grep kvm
```
> Output: `kvm AND (kvm_amd OR kvm_intel)`

11.12.3 QEMU (Quick EMUlator and virtualizer)

https://wiki.archlinux.org/title/QEMU
OPT: https://wiki.archlinux.org/title/QEMU#Using_an_entire_physical_disk_device_inside_the_VM

For x86_64:
```
doas pacman -S qemu-desktop;
```

11.12.4 libvirt (virtual machine manager)

https://wiki.archlinux.org/title/Libvirt
https://wiki.libvirt.org/page/FAQ

Note: "Libvirt now makes storage pools nocow when on btrfs automatically" – Source.
Note: Libvirt installs a zone called 'libvirt' in firewalld and manages its required network rules there.

11.12.4.1 Installation

Default NAT/DHCP networking:

```
doas pacman -S --needed --asdeps dnsmasq iptables-nft;
```

TPM emulator & DMI system info:

```
doas pacman -S --needed --asdeps swtpm dmidecode;
```

libvirt:

```
doas pacman -S libvirt;
```

11.12.4.2 Bypass password prompt

https://wiki.archlinux.org/title/Polkit#Bypass_password_prompt

```
doas vim /etc/polkit-1/rules.d/49-nopasswd_global.rules
>
/* Allow members of the wheel group to execute the defined actions
 * without password authentication, similar to "sudo NOPASSWD:"
 */
polkit.addRule(function(action, subject) {
        if ((action.id == "org.libvirt.unix.manage") &&
                subject.isInGroup("wheel"))
        {
                return polkit.Result.YES;
        }
});
```

11.12.4.3 Enable socket (for QEMU)

```
doas systemctl enable --now libvirtd.socket;
```

11.12.4.4 Reboot (as an advice)

```
systemctl reboot
```

11.12.4.5 Change default storage pool location

Note: Whenever a new domain is created, the ownership should be adjusted: `root` ⇨ `1000`.

Shutdown the domains & type:

```
doas chown 1000:1000 ~/.local/share/libvirt/images/*;
```

11.12.4.5.1 Do not dynamically change qcow2 file ownership at runtime

… if the virtualization is done by only one user.

```
doas vim /etc/libvirt/qemu.conf
```

> Uncomment:

```
  user = "username"
  group = "username"
```

11.12.4.5.2 Destroy & undefine default storage pool "/var/lib/libvirt/images/"

… if the *default* pool has been defined.

```
doas virsh pool-destroy default;
doas virsh pool-undefine default;
```

11.12.4.5.3 Create a new default storage pool

```
mkdir -p ~/.local/share/libvirt/images;
Disable CoW: chattr +C ~/.local/share/libvirt/images/;
doas virsh pool-define-as --name default --type dir --target
~/.local/share/libvirt/images;
```

11.12.4.5.4 Autostart default pool

```
doas virsh pool-autostart default;
doas virsh pool-start default;
```

11.12.4.6 Create a storage pool for ISO images

```
mkdir ~/Downloads/ISO;
doas chown 1000:libvirt-qemu ~/Downloads/ISO/;
doas virsh pool-define-as --name ISO --type dir --target ~/Downloads/ISO/;
doas virsh pool-autostart ISO;
doas virsh pool-start ISO;
```

11.12.4.7 Enable default network (virbr0)

```
doas virsh net-start default;
doas virsh net-autostart default;
```

11.12.5 Virt-Manager (GUI Client)

https://wiki.archlinux.org/title/Virt-Manager

Tip: Use snapshots in Virt-Manager.

`virt-manager`

11.12.5.1 Preferences

Edit **> Preferences:**

- General **> Check** "Enable XML editing"
- New VM **> x86 Firmware:** UEFI

11.12.5.2 VM configuration (using QEMU/KVM)

Note: Before finishing the VM creation process **> Check** "Customize configuration before install":

11.12.5.2.1 Overview (for Secure Boot)

- **Firmware:** `UEFI x86_64: …/x64/OVMF_CODE.secboot.4m.fd`

11.12.5.2.2 CPUs (Here: 4C/8T)

- Topology **> Sockets:** 1, **Cores:** 4, **Threads:** 2

11.12.5.2.3 Storage (e.g. VirtIO Disk)

- Change sector size to 4K (for 4Kn) **> Edit XML** of Disk:

```
<disk type="file" device="disk">
  …
  <blockio logical_block_size="4096" physical_block_size="4096"/>
</disk>
```

11.12.5.2.4 Enable 3D acceleration (not for Windows)

- **Video > Model:** Virtio **& Check** "3D acceleration"
- **Display > Check** "OpenGL" **& Listen Type:** "None"

11.12.5.3 Enable Secure Boot (after VM creation)

https://wiki.archlinux.org/title/KVM#Secure_Boot
https://gitlab.com/kraxel/virt-firmware

`virt-firmware`

11.12.5.3.1 Enroll default (Microsofts & RedHats) SB keys to a new variable store

```
virt-fw-vars --input /var/lib/libvirt/qemu/nvram/vm-name_VARS.fd --output
/var/lib/libvirt/qemu/nvram/vm-name_VARS.secboot.fd --enroll-redhat --secure-
boot;
```

11.12.5.3.2 Point to the new variable store > Edit XML:

```
<os firmware="efi">
...
  <loader readonly="yes" secure="yes"
type="pflash">/usr/share/edk2/x64/OVMF_CODE.secboot.4m.fd</loader>
  <nvram template="/usr/share/edk2/x64/OVMF_VARS.4m.fd">/var/lib/libvirt/qemu/
nvram/vm-name_VARS.secboot.fd</nvram>
</os>
```

11.12.5.3.3 Verify SB status

… e.g. in the UEFI firmware setup utility.

11.12.6 Windows 11 VM (using virtio, QEMU/KVM)

https://kevinlocke.name/bits/2021/12/10/windows-11-guest-virtio-libvirt/

Note: The graphics performance is not great in MS Windows. Passthrough a GPU instead.

Note: To hide the "virtualization state", you should not use virtio-win (see below).

11.12.6.1 "Create a new virtual machine"

- **Local install media:** `win11.iso`

11.12.6.2 Storage config

- **SATA Disk 1 > Disk bus:** VirtIO
- **Add Hardware > Storage**
  - **Device type:** CDROM
  - **Manage (Select storage):** ISO (pool) **> Choose:** `virtio-win.iso`

11.12.6.3 NIC (Network Interface Card)

- **Device model:** virtio

11.12.6.4 "Begin Installation" (Boot from CD/ISO)

- **Press some keys** to boot from the ISO because the message may not appear (black screen)
- **Choose** "Custom: Install Windows only (advanced)"
  - **For VirtIO Disk:** Load driver **>** OK **> Select:** `\amd64\w11\viostor.inf`
  - **Select:** Drive 0 Unallocated Space **>** Next **>** … **>** Complete installation

11.12.6.5 Install virtio drivers

- **Open CD/ISO** `virtio-win` **> Execute** `virtio-win-guest-tools.exe` **> Reboot**

11.13 Containerization – Podman

https://wiki.archlinux.org/title/Podman

… is an alternative to Docker, providing a similar interface, but is more secure by default.

`podman`

11.13.1 Registries

```
doas vim /etc/containers/registries.conf.d/10-unqualified-search-registries.conf
> unqualified-search-registries = ["docker.io"]
```

11.13.2 OPT: Implementation of the Compose Spec [deps]

`podman-compose`

11.13.3 Podman Desktop (GUI)

https://podman-desktop.io/

… is open-source too, unlike Docker Desktop.

`podman-desktop`

11.14 mpv (media player)

https://wiki.archlinux.org/title/mpv
https://github.com/mpv-player/mpv/wiki

… is stable, efficient, customizable and extensible via user scripts.

Note: Configuring mpv to your personal requirements *can* be very time-consuming. For an easier start, take a look at my configuration files.

11.14.1 Installation

```
doas pacman -S --needed --asdeps yt-dlp aria2;
doas pacman -S mpv mpv-mpris;
```

11.14.2 Configuration

- User settings
  `~/.config/mpv/mpv.conf`
- Key bindings (defaults)
  `~/.config/mpv/input.conf`

11.14.3 *My* settings

… as shown in my config files like extended key bindings, better audio & subtitles, more QoL, etc.

11.14.3.1 Video scaling (preference)

Reference: mpv Resampling
> Experimental (Hit or Miss): FSRCNNX, SSimSuperRes, SSimDownscaler, KrigBilateral
> scale=dscale=cscale=**lanczos**

Good alternative upsampling shader: ravu-zoom-ar-r3 (in `gather/` or `compute/`)

11.14.3.2 Frame interpolation (preference)

Reference: SVP 4 Setup Guide for Smooth “60 FPS” Anime Playback (2019)
> Setting B: I Hate Soap Opera Edition

11.15 Windows 11 – Minimal Setup

11.15.1 General

- **Enable** Secure Boot
- **Activate** Windows **>** **Update** Windows & Apps
- Enable virtualization-based protection of code integrity

11.15.2 Debloat

- https://privacy.sexy **>** Standard settings **>** Download & Execute script **>** Reboot
- **Uninstall** more apps **>** **Debloat** more (esp. use `gpedit` & `regedit`)

11.15.3 "Package managers"

11.15.3.1 winget

https://learn.microsoft.com/windows/package-manager/winget/

… to manage esp. UWP apps from the Microsoft Store.

Install apps:
… like: `firefox kate okular filelight`

```
winget install -s msstore <apps>
```

Upgrade all apps:

```
winget upgrade -rh
```

11.15.3.2 Scoop

https://scoop.sh/

… downloads and manages packages in a portable way, keeping them neatly isolated in ~\scoop.

Install apps:
… like: `<todo>`

```
scoop install <apps>
```

Upgrade all apps:

```
scoop update --all
```

11.16 Waydroid

https://wiki.archlinux.org/title/Waydroid

… is a container-based approach to boot a full Android system on a regular GNU/Linux system.

- **REQ for easy setup (2024):** AMD/Intel GPU, Wayland, linux{,-lts,-zen}

`waydroid`

11.16.1 Init Waydroid

- **Start** "Waydroid" **> Download** the VANILLA or GAPPS version **> Done**

11.16.2 Adjust firewalld

https://wiki.archlinux.org/title/Waydroid#Network

```
doas firewall-cmd --zone=trusted --add-port=67/udp;
doas firewall-cmd --zone=trusted --add-port=53/udp;
doas firewall-cmd --zone=trusted --add-forward;
doas firewall-cmd --zone=trusted --add-interface=waydroid0;
doas firewall-cmd --runtime-to-permanent;
```

11.16.3 Enable (or only Start) the Waydroid session

```
doas systemctl enable --now waydroid-container.service;
```

11.16.4 Launch GUI

Start "Waydroid" **or**:

```
waydroid show-full-ui
```

11.16.5 Google Play Certification (for GAPPS)

> https://docs.waydro.id/faq/google-play-certification

11.16.6 Upgrade images

```
doas waydroid upgrade
```

11.17 Rust (using rustup, for devs)

https://wiki.archlinux.org/title/Rust

11.17.1 Learn Rust

https://www.rust-lang.org/learn

- A half-hour to learn Rust
- "The Book"
- RustRover Academy Course
- Rust By Example

11.17.2 Install rustup & its stable toolchain

https://wiki.archlinux.org/title/Rust#Rustup

```
doas pacman -S rustup;
rustup default stable;
```

11.17.3 Tools: rust-analyzer, Clippy & rustfmt

https://wiki.archlinux.org/title/Rust#Tools

```
rustup component add rust-analyzer rust-src;
```

- **Language Server Protocol:** rust-analyzer (rust-src is required)
- **Collection of lints:** Clippy (built-in)
- **Formatting Rust code according to style guidelines:** rustfmt (built-in)

11.17.4 IDE – JetBrains RustRover

https://www.jetbrains.com/rust/
https://wiki.archlinux.org/title/Rust#Editors

`rustrover`[AUR] `rustrover-jre`[AUR]

- Enable Clippy
- GitLab

11.17.5 Update Rust toolchains

```
rustup update;
```

11.18 OPT: Easy Effects (for EQ & more)

https://wiki.archlinux.org/title/PipeWire#EasyEffects
https://github.com/wwmm/easyeffects

`easyeffects` `calf` `lsp-plugins-lv2`

11.18.1 Presets

https://github.com/wwmm/easyeffects/wiki/Community-presets

11.18.1.1 Import Input/Output preset

Open Easy Effects **>** Presets **>** In/Output **>** "**Import** a preset" & Select *`preset`*`.json` **>** **Load** preset

11.18.1.2 Input preset: For male voices w/ noise reduction [2023-07]

Download: https://github.com/jtrv/.cfg/blob/morpheus/.config/easyeffects/input/fifine_male_voice_noise_reduction.json

… from "Improved Microphone (Male voices, with Noise Reduction) EasyEffects preset".

11.18.2 Equalizer (EQ)

… e.g. to change the headphones frequency response target, to simulate different headphones or to enhance the bass.

Note: To achieve the best audio quality possible, you should use "bit-perfect playback".

11.18.2.1 Import "EqualizerAPO ParametricEQ" preset

Add Effect: "Equalizer" **> Import Preset:** APO **> Select:** *`ParametricEQ`*`.txt`

11.18.2.2 AutoEq (Here: Simulating headphones)

> Wiki#Can I use AutoEq to simulate a different headphone?

Q: Why simulating headphones instead of using a frequency response target?
> Because the *Harmman* targets are quite bass-heavy, and *Diffuse Field* targets are lacking in bass.

Note: As a good starting point, you can simulate the "Sennheiser HD 800 S" (for over-ear headphones) and adjust the bass.

- **Go to:** https://autoeq.app
- **Select headphones** *to simulate*
- **Profiles > Show advanced:**
  Sound signature **>** Click on 🎧
- **Select** *your* **headphones**
- **Select equalizer app:** "EqualizerAPO ParametricEq" **> Download** *`ParametricEQ`*`.txt`

11.19 AI / LLM

… using the GPU w/ CUDA or ROCm support.

Note: The higher the parameters of a model, the more VRAM is usually required.

11.19.1 REQ

https://rocm.docs.amd.com/projects/radeon/en/latest/docs/install/native_linux/howto_native_linux.html

11.19.1.1 Disable AMD iGPU in SBIOS (for AMD ROCm on Radeon GPUs)

… to avoid unknown issues.

For AM5 platforms:

- Advanced **>** AMD CBS **>** NBIO Common Options **>** GFX Configuration **>** iGPU Configuration **or**
- Advanced **>** NB Configuration **>** Integrated Graphics

11.19.1.2 PyTorch

https://pytorch.org/

… is an optimized tensor library for deep learning using GPUs and CPUs.

Note: The `torchvision` package consists of popular datasets, model architectures, and common image transformations for computer vision.

- **AMD ROCm:** `python-pytorch-opt-rocm` `python-torchvision-rocm`[AUR] **or**
- **NVIDIA CUDA:** `python-pytorch-opt-cuda` `python-torchvision-cuda`

Verify support:

```
python -c 'import torch; print(torch.cuda.is_available())'
>> True
```

11.19.1.3 ONNX Runtime (for e.g. Firefox AI Runtime)

https://onnxruntime.ai/

"ONNX Runtime is a cross-platform machine-learning model accelerator, with a flexible interface to integrate hardware-specific libraries. ONNX Runtime can be used with models from PyTorch, Tensorflow/Keras, TFLite, scikit-learn, and other frameworks."

- **AMD ROCm:** `python-onnxruntime-opt-rocm` **or**
- **NVIDIA CUDA:** `python-onnxruntime-opt`

Verify support for ROCm:

```
python -c 'import onnxruntime as ort; print(ort.get_available_providers())'
>> ['ROCMExecutionProvider', 'DnnlExecutionProvider', 'CPUExecutionProvider']
```

11.19.2 Text generation: Ollama

https://github.com/ollama/ollama

… is a framework designed to e.g. easily run & usually manage smaller LLMs locally.

- **AMD ROCm:** `ollama-rocm` **or**
- **NVIDIA CUDA:** `ollama-cuda`

11.19.2.1 Enable service

```
doas systemctl enable --now ollama.service
```

11.19.2.2 Get spezialized & suitable model

Note: Not all models might be optimized for GPU use, so performance benefits can vary.

Parameters	~VRAM
7B	8 GB
13B	16 GB
33B	32 GB

11.19.2.3 For math, code, and reasoning tasks: DeepSeek R1

https://huggingface.co/deepseek-ai/DeepSeek-R1-Distill-Qwen-14B
> Distilled Model Evaluation

Note: The open-source 32b model can also be used w/ only 16 GB VRAM, but it is (very) slow.

```
ollama pull deepseek-r1:14b
```

11.19.2.4 Integrations

11.19.2.4.1 JetBrains IDE: AI Assistant

https://www.jetbrains.com/ai-assistant/

Install JetBrains AI Assistant plugin

Tools **>** AI Assistant **> Models:**

Third-party AI providers:

- **Enable Ollama**
- **URL:** http://localhost:11434
- **Test Connection**

Local models:

- **Core features:** ollama/deepseek-r1:14b
- **Instant helpers:** <todo>

11.19.2.4.2 Zed

> https://zed.dev/docs/ai/configuration

11.19.3 Speech recognition: Whisper

https://github.com/openai/whisper

Note: For the large model with multilingual support, you need ~10 GB VRAM.

`python-openai-whisper`

11.19.3.1 Example: Transcribe the German speech of the audio file

```
whisper --model large --output_format all --task transcribe --language de
<audio>
```

11.19.3.2 Example: Generate English translated subtitle track

```
whisper --model large --output_format srt --task translate --language ja
<file.mkv>
```

12 Hardware specific

12.1 Sensors

https://wiki.archlinux.org/title/Lm_sensors

12.1.1 Setup

Note: Only use default options (by just hitting `enter`), unless you know exactly what you are doing.

```
doas sensors-detect
> enter
```

12.1.2 Check sensors

```
sensors
```

> No mainboard sensors?: https://wiki.archlinux.org/title/Lm_sensors#Troubleshooting

12.1.3 Tip: Print sensors values periodically

```
watch sensors
```

12.2 OPT: Fan speed control

> https://wiki.archlinux.org/title/Fan_speed_control

12.3 OPT: Stress testing

> https://wiki.archlinux.org/title/Stress_testing

12.4 MFP: Printer & Scanner

REQ: Your device should support:

- **Printing:** IPP Everywhere (AirPrint devices should work too)
  IPP Everywhere is an open standard. The proprietary AirPrint implements parts of IPP E.
- **Scanning:** eSCL (Apple AirScan, AirPrint scanning) **or**
  Microsoft WSD (Web Services for Devices, WS-Scan)
  The eSCL & WSD specifications are open. There is currently no open standard for scanning.

12.4.1 Printer (CUPS over IPP Everywhere)

https://wiki.archlinux.org/title/CUPS
https://wiki.archlinux.org/title/CUPS/Printer-specific_problems

`cups` `cups-pdf` `system-config-printer`

```
> doas systemctl enable cups.socket
```

Note: You can also connect your device over USB by installing `ipp-usb`.

```
> doas systemctl enable ipp-usb.service
```

12.4.2 Scanner (SANE)

https://wiki.archlinux.org/title/SANE
https://wiki.archlinux.org/title/SANE/Scanner-specific_problems

`sane` `sane-airscan`

12.4.3 Setup your device (manually after reboot)

Example setup of the "**Brother MFC-L3760CDW**", which supports AirPrint, eSCL, IPPS & HTTPS. So you do not need `brother-mfc-l3760cdw`[AUR] (LPR printer driver) & `brscan5`[AUR] (scanner driver).

- **Set static IP address** in your router (e.g. **192.168.178.13**)
- **Update the printer's firmware** by logging in to its web interface (e.g. at https://192.168.178.13, using the default password)

12.4.4 Setting up a network printer (w/o cups-browsed & Avahi)

```
lpadmin -p Brother_MFC-L3760CDW -E -v "ipps://192.168.178.13/ipp/print" -m
everywhere;
```

ALT: Open the CUPS administration interface at https://localhost:631/admin

> Add Printer:

- **Network Printer:** Internet Printing Protocol (ipps)
- **Connection:** ipps://192.168.178.13/ipp/print
- **Driver:** IPP Everywhere

12.4.5 Setting up a network scanner (from another domain)

Tip – Get eSCL scanner capabilities: Go to http://192.168.178.13/eSCL/ScannerCapabilities

Note: If your network is split into several broadcast domains, get the correct address for manual configuration to be able to scan from other domains.

12.4.5.1 Get address of the scanner (in the same domain)

Connect a PC to the same broadcast domain as your scanner **& Execute:**

```
airscan-discover
>
[devices]
  Brother MFC-L3760CDW series = http://192.168.178.13:80/eSCL/, eSCL
  Brother MFC-L3760CDW series = https://192.168.178.13:443/eSCL/, eSCL
  Brother MFC-L3760CDW series =
http://192.168.178.13:80/WebServices/ScannerService, WSD
```

12.4.5.2 Manual add scanner entry

```
doas vim /etc/sane.d/airscan.conf
>
[devices]
"Brother MFC-L3760CDW" = https://192.168.178.13:443/eSCL
```

12.5 Fingerprint reader

> https://wiki.archlinux.org/title/Fprint (Supprted devices)

> For SDDM: https://wiki.archlinux.org/title/SDDM#Using_a_fingerprint_reader

`fprintd` `imagemagick`

12.6 RGB Control

> OpenRGB**:** https://openrgb.org/devices.html

`openrgb`

12.7 Peripherals

12.7.1 Mice

Info: https://sensor.fyi/info/

Note: Mice like the ones from Zowie do not need any software to change the CPI.

Software	Supported mice
`piper`	https://github.com/libratbag/libratbag/tree/master/data/devices

12.7.2 Keyboards

Software	Supported keyboards
`qmk`	**(Custom) keyboards:** https://qmk.fm/keyboards/

12.7.3 Logitech peripherals – Solaar

> Solaar**:** https://pwr-solaar.github.io/Solaar/devices (partial list)

`solaar`

12.7.4 Razer peripherals – OpenRazer

> https://wiki.archlinux.org/title/Razer_peripherals#OpenRazer

12.8 Display – Setup (OLED?, HDR, Calibration)

12.8.1 OLED vs LCD

12.8.1.1 OLED – Pros

- **Near-zero pixel response time**. Higher rating of VESA ClearMR (≥21000)
- **Superior contrast** than LCDs. Better HDR experience

12.8.1.2 OLED – Cons (as of 2025)

- Usually, for each pixel row, there is a very brief decrease in pixel brightness with the frequency of the display's refresh rate. In this sense, the **OLEDs aren't technically flicker-free** and *can* cause eyestrain, headaches, etc. if you're sensitive to flicker.
- WQHD OLED displays have **lower text clarity**
- The **brightness *can* change automatically** to mitigate the Burn-in
  ⇨ E.g. enable "Uniform Brightness (UB)" on an ASUS monitor, but which will reduce the max luminance
- **Variable Refresh Rate (VRR) should be disabled**, since it introduces visual flickering

12.8.2 Calibration

Note: HDR ICC Color Profiles are currently not supported by KDE Plasma. So the focus is SDR.

Info – for HDR: See Rec. 2100 (w/ other transfer function).

12.8.2.1 Display settings

Note: Update display firmware & Reset to default monitor settings.

- **Transfer function – Gamma:** 2.2 (for web & gaming ⇨ for Rec. 709 and Rec. 2020)
  … for SDR.
- **White point (Color temperature):** 6500K aka. D65 (spec of Rec. 709 and Rec. 2020)
- **Color gamut (Color space):** Set widest gamut ["Wide gamut", "BT.2020"]
- **Recommended:** Disable all dynamic image functionalities
  - **Enable** "Uniform Brightness"
  - **Disable** "Black Frame Insertion (BFI)" aka. ELMB, ULMB, DyAc, LightBoost, etc.
    … which would also introduce a flicker w/ a frequency of f_flicker = f_display / 2

12.9 Hardware Security Key – Nitrokey 3

Features: https://docs.nitrokey.com/nitrokey3/features
Example: Nitrokey 3C NFC

https://wiki.archlinux.org/title/Nitrokey
https://docs.nitrokey.com/nitrokey3/linux/

Note: The subsequent key generation and storage should take place in a secure environment (preferably without Internet access).

- **Nitrokey:** `python-pynitrokey`
- **OPT:** Nitrokey App2
```
flatpak install flathub com.nitrokey.nitrokey-app2
```
- **FIDO2:** `pam-u2f` `libfido2`

12.9.1 Update & Test the firmware

https://docs.nitrokey.com/nitrokey3/linux/firmware-update

```
nitropy nk3 update
```
> Touch the device to activate the bootloader

```
nitropy nk3 test --pin <FIDO2 pin>
```

12.9.2 OpenPGP smartcard

https://wiki.archlinux.org/title/OpenPGP-card-tools

`openpgp-card-tools` `kleopatra`

```
doas systemctl enable --now pcscd.socket;
```

12.9.2.1 Setup GnuPG w/ pcscd (PCSC Lite)

https://wiki.archlinux.org/title/GnuPG#GnuPG_with_pcscd_(PCSC_Lite)

```
mkdir ~/.gnupg;
vim ~/.gnupg/scdaemon.conf
```
>
```
disable-ccid
pcsc-shared
```

```
gpgconf --reload scdaemon;
```

12.9.2.2 Verify Ed25519/Curve25519 support (for OpenPGP Key Generation)

```
oct info
```
> Verify supported algorithms:
```
- SIG: Ed25519 (EdDSA)
- DEC: Cv25519 (ECDH)
- AUT: Ed25519 (EdDSA)
```

12.9.2.3 OpenPGP Key Generation With Backup

https://docs.nitrokey.com/nitrokey3/linux/openpgp-keygen-backup

12.9.2.3.1 Main Key and Encryption Subkey

A main key with the capability to sign and certify [SC] and a subkey for encryption [E] will be generated.

```
gpg --full-generate-key --expert
```

1. **Please select what kind of key you want:**
   (**9**) ECC (sign and encrypt) *default*
2. **Please select which elliptic curve you want:**
   (**1**) Curve 25519 *default*
3. **Please specify how long the key should be valid:**
   7y. **Note:** You can also extend the validity after the expiry date in e.g. Kleopatra.
   > Is this correct? (y/N) **y**
4. **GnuPG needs to construct a user ID to identify your key:**
   > Enter Real name
   > Enter Email address
   > Enter (Skip Comment)
   > (**O**)kay
5. A pop-up will appear asking you to **enter a secure password** to secure the keys.
   > gpg: revocation certificate stored as '~/.gnupg/openpgp-revocs.d/<cert>.rev'

12.9.2.3.2 Subkey for Authentication

```
gpg --edit-key --expert <email>
```

```
gpg> addkey
```

1. **Please select what kind of key you want:**
   (**11**) ECC (set your own capabilities)
2. **Possible actions for this ECC key:** Sign Authenticate
   Current allowed actions: Sign
   1. (**S**) Toggle the Sign capability … to remove Sign
   2. (**A**) Toggle the Authenticate capability
   3. (**Q**) Finished
3. **Please select which elliptic curve you want:**
   (**1**) Curve 25519 *default*
4. **Please specify how long the key should be valid:**
   7y
5. Is this correct? (y/N) **y**
   Really create? (y/N) **y**
6. gpg> **quit**
   Save changes? (y/N) **y**

12.9.2.3.3 Backup keys

```
mkdir sec-keys; cd sec-keys;
gpg --armor --output privkey_<email>.asc --export-secret-key <email>;
gpg --armor --output subkeys_<email>.asc --export-secret-subkeys <email>;
gpg --armor --output pubkey_<email>.asc --export <email>;
gpg --export-ownertrust > <email>.txt;
gpg --output revoke_<email>.asc --gen-revoke <email>
```

12.9.2.3.4 Import Keys into your OpenPGP card (after key generation)

```
gpg --edit-key --expert <email>
```

>

Import Main key

```
gpg> keytocard
```

1. Really move the primary key? (y/N) **y**
   Please select where to store the key:
   (**1**) Signature key
   > Enter (default) Admin PIN: 12345678

Import Encryption subkey

```
gpg> key 1 (*Select the Encryption subkey)
gpg> keytocard
```

1. **Please select where to store the key:**
   (**2**) Encryption key

Import Authentication subkey

```
gpg> key 1 (Deselect the Encryption subkey)
gpg> key 2 (*Select the Authentication subkey)
gpg> keytocard
```

1. **Please select where to store the key:**
   (**3**) Authentication key

Quit & Save

```
gpg> quit
```

> Save changes? (y/N) **y**

12.9.2.3.5 Import the public key on each system that shall use the OpenPGP card

```
gpg --import pubkey_<email>.asc
gpg --import-ownertrust <email>.txt
```

And link the keys stored on the smartcard to the local GnuPG-KeyRing:

```
gpg --card-status
```

12.9.2.4 FYI: Import the secured Private Key into your OpenPGP card

```
oct admin --card <card ident> import privkey_<email>.asc
```

> Enter Admin PIN

> Enter password for signing (sub)key

12.9.2.5 Set PINs

Note: Every PIN has a retry counter of 3 attempts. If these attempts are used up for the *Admin PIN*, the *OpenPGP Card* can not be used anymore and must be reset to factory defaults.

Check Remaining PIN attempts:

```
oct status | grep PIN
```

List card ident (`0123:01234567`):

```
oct list -i
```

Set User PIN (for decryption, signing, authentication, update validity, …):

```
oct pin --card <card ident> set-user
```

Set Admin PIN (for importing an OpenPGP key, to unblock the User PIN & Reset Code, …):

```
oct pin --card <card ident> set-admin
```

Set Reset Code (only to unblock the User PIN):

```
oct pin --card <card ident> set-reset
```

Later: Unblock the User PIN:

```
oct pin --card <card ident> reset-user-rc
ALT: oct pin --card <card ident> reset-user
```

12.9.2.6 OPT: Factory reset the OpenGPG card

```
oct system factory-reset --card <card ident>
```

12.9.3 FIDO2

https://wiki.archlinux.org/title/Universal_2nd_Factor

12.9.3.1 List device (device = PATH = e.g. /dev/hidraw2)

```
systemd-cryptenroll --fido2-device=list
```

12.9.3.2 Set PIN

Set PIN:

```
nitropy fido2 set-pin
ALT: fido2-token -S <device>
```

Change PIN:

```
nitropy fido2 change-pin
ALT: fido2-token -C <device>
```

12.9.4 SSH Keys

https://wiki.archlinux.org/title/SSH_keys

12.9.4.1.1 Enable ssh-agent user service

https://wiki.archlinux.org/title/SSH_keys#SSH_agents

```
systemctl enable --now --user ssh-agent.service;
```

```
doas vim /etc/security/pam_env.conf
```

> Append:

```
# ssh-agent with systemd user
SSH_AUTH_SOCK   DEFAULT=${XDG_RUNTIME_DIR}/ssh-agent.socket
```

12.9.4.1.2 Generate a public/private FIDO2 Key Pair

https://wiki.archlinux.org/title/SSH_keys#FIDO/U2F

Current bug w/ -O verify-required:
https://wiki.archlinux.org/title/SSH_keys#agent_refused_operation

Note: The “private key” only refers to the hardware key. Therefore, you can leave the passphrase empty when generating the following key pair.

```
ssh-keygen -t ed25519-sk -O resident -O application=ssh:nitrokey
```

> Enter PIN **&** Touch token
> Enter (file name: `~/.ssh/id_ed25519_sk`)
> Enter (**no** passphrase)

12.9.4.1.3 Add the "private key" to ssh-agent´s cache

```
ssh-add ~/.ssh/id_ed25519_sk
```

12.9.4.1.4 Add the "public key" to a remote server (w/ installed OpenSSH)

```
ssh-copy-id -i ~/.ssh/id_ed25519_sk.pub user@host
```

12.9.4.1.5 Git integration

E.g. GitLab: https://gitlab.com/-/user_settings/ssh_keys
> Add new (public) key: `sk-ssh-ed25519@openssh.com ... username@hostname`

Test:

```
ssh -T git@gitlab.com
```

> Enter PIN for ED25519-SK key
> Confirm user presence for key ED25519-SK

12.9.5 HMAC-SHA1 challenge-response credential

… e.g. to be able to secure your KeePassXC database.

12.9.5.1 Create a 20 byte secret & Backup this secret

```
doas pacman -S pwgen;
pwgen --capitalize --numerals --secure 19 1 > hmac-sec.txt;
```

12.9.5.2 Convert secret to base32 & Register credential to HMAC slot 2

```
nitropy nk3 secrets add-challenge-response 2 $(cat hmac-sec.txt | base32)
```

12.9.5.3 Protect your existing KeePassXC database

https://docs.nitrokey.com/nitrokey3/linux/keepassxc

Database **>** Database Security **>** Add additional protection **>** Add Challenge-Response **>** OK

12.10 Computer Hardware Recommendations

12.10.1 Mainboard

- **Sensor drivers** maybe available (a bit later after release) for [1]
  > https://wiki.archlinux.org/title/Lm_sensors#Troubleshooting
- **NIC (Ethernet & Wireless):** Intel **>** Realtek
- **Audio:** See alsa-ucm-conf/issues

12.10.2 Discrete GPU (dGPU)

12.10.2.1 For Gaming

- AMD **>>** NVIDIA (causes problems quite often, also proprietary) **>** Intel (new)

12.10.2.2 For Computing

> https://wiki.archlinux.org/title/GPGPU

- AMD *recommends* 64GB RAM & 24GB VRAM required for complex AI/ML workloads

12.10.3 CPU

12.10.3.1 Notes

- Minor performance degradation due to future microcode mitigations**:** AMD (-) **>** Intel (--)

12.10.3.2 For hardware-isolated virtualization

See: Virtualization

- AMD Pro CPU w/ SEV
- Intel CPU w/ TDX or SGX2

12.10.3.3 Esp. for PCI passthrough via OVMF

- CPU w/ iGPU (integrated graphics)

12.10.4 Display

- VESA standards
  - **For Gaming:** ClearMR (Certified Products)
  - DisplayHDR (Certified Products)
- Overclocked panels ("OC mode") *can* cause issues
- DisplayPort (DP) **>** HDMI

12.10.5 Disk

- 4Kn ≥ 512e/4Kn **>** 512e **>** 512n …n = native, e = emulation (**See:** Advanced Format)
- **External backup disk:** Internal HDD (non-SMR) + UASP USB case

13 Disks & Data

Change disk: `/dev/sdb`
Change disk name: ***myData*** (**e.g.:** "Vendor name" + "disk size" = e.g. *Seagate20*)
⇨ **dm_name:** ***myData***
⇨ **mount point:** `/mnt/myData` (**OPT:** Change to e.g. "Data" for compatibility with future drives)

13.1 Preparing the disk (as *root*)

> Follow instructions of "Preparing the disk" from "Pre-installation" with `/dev/sdb`

13.2 Setup encrypted internal disk (as *root*)

13.2.1 Create the LUKS encrypted container w/ passphrase

https://wiki.archlinux.org/title/Dm-crypt/Device_encryption#Encryption_options_for_LUKS_mode

```
cryptsetup luksFormat --label myData /dev/sdb
> YES
> fallback-password
```

OPT – Verify sector size:

```
cryptsetup luksDump /dev/sdb | grep sector
```

13.2.2 Add a keyfile (for crypttab)

https://wiki.archlinux.org/title/Dm-crypt/Device_encryption#Keyfiles

13.2.2.1 Creating a keyfile with random characters

If the "keyfile directory" does not exist yet:

```
mkdir /etc/cryptsetup-keys.d;
```

```
dd bs=512 count=4 if=/dev/random iflag=fullblock | install -m 0600
/dev/stdin /etc/cryptsetup-keys.d/myData.key;
```

13.2.2.2 Add the keyfile to "key-slot 1" of the LUKS header

```
cryptsetup luksAddKey /dev/sdb /etc/cryptsetup-keys.d/myData.key
> fallback-password
```

13.2.3 Open the LUKS container

```
cryptsetup open /dev/sdb myData --key-file /etc/cryptsetup-keys.d/myData.key;
```

13.2.4 Format the (unlocked LUKS) device

```
mkfs.btrfs -L myData /dev/mapper/myData;
```

13.2.5 OPT: Choose a suitable zstd compression level (for mount)

13.2.5.1 Get test-package (Here: pacman package)

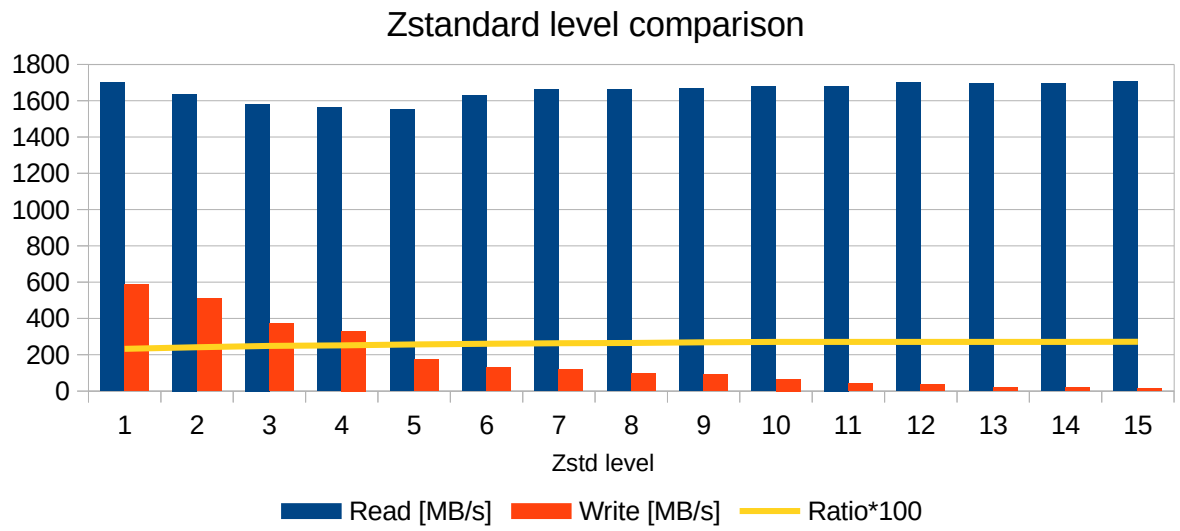
```
cp /var/cache/pacman/pkg/<package>.pkg.tar.zst /tmp/ && cd /tmp/;
unzstd <package>.pkg.tar.zst
```

13.2.5.2 Benchmark

```
for j in {1..15}; do zstd -b$j -T0 <package>.pkg.tar; done
```

13.2.5.3 Example

Package: `libreoffice-still-7.3.6-4-x86_64.pkg.tar` **| Zstd version:** `v1.5.2`



Zstd level	Read [MB/s]	Write [MB/s]	Ratio*100
1	1702	586	233
2	1637	510	242
3	1582	374	249
4	1565	331	252
5	1552	174	257
6	1630	128	261
7	1661	118	264
8	1662	96	265
9	1666	91	269
10	1677	66	271
11	1681	42	271
12	1701	36	271
13	1693	21	271
14	1696	19	271
15	1706	15	272

13.2.6 Get mount options (for fstab)

13.2.6.1 Mount the btrfs volume

READ: https://wiki.archlinux.org/title/Security#Mount_options

OPT – Increase compression level (≥4), change: `compress=zstd:4`

```
mount -m -o compress=zstd,nosuid,nodev,noexec /dev/mapper/myData /mnt/myData
```

13.2.6.2 Note mount options (for fstab)

```
mount | grep myData
> ... btrfs (<mount_options>)
```

13.2.7 Change owner to "user:primary_usergroup"

```
chown -Rc $(logname): /mnt/myData;
```

13.2.8 Automount keyfile encrypted disk

Note: With the following config, the system can only boot when the disk is attached.

13.2.8.1 Crypttab

https://wiki.archlinux.org/title/Dm-crypt/System_configuration#crypttab

Note: *<Output of <command> in vim (normal mode) using ":r! <command>">*

```
vim /etc/crypttab
>
myData    UUID=<blkid -o value -s UUID /dev/sdb>         /etc/cryptsetup-keys.d/myData.key
```

13.2.8.2 Fstab

https://wiki.archlinux.org/title/Fstab

Note – for Btrfs: `fs_passno=0` instead of `2`.

```
vim /etc/fstab
>
# myData
/dev/mapper/myData          /mnt/myData        btrfs     <mount_options>    0 0
```

13.2.8.3 Test crypttab & fstab

```
umount /mnt/myData;
cryptsetup close myData;
systemctl daemon-reload;
systemctl start systemd-cryptsetup@myData.service;
mount -a
```

```
OPT: systemctl reboot
```

13.3 TODO – OPT: Directory structure of your private data

… for faster navigation.

- `COLL/` – Collections (no music/video coll.)
- `DWNLD/` – Downloads
- `IMP/` – Important stuff
- `MUSIC/` – Music coll.
- `VID/` – Video coll.

13.4 TODO: Create a backup plan

https://wiki.archlinux.org/title/Synchronization_and_backup_programs

Recommendations:

- BorgBackup: `borg`
- restic: `restic`
- Kopia: `kopia-ui-bin`[AUR]

13.4.1 Demands

- **Type of backup medium:** External hard drive
- **Planned frequency of backups:** Weekly, Monthly
- **Important:** Encrypted & Compressed storage; Handles FS metadata & renames
- **Nice2Have:** Resumable, Fast (Delta transfer, Multithreaded), Snapshots
- **What will be backed up:**
  - Selected disks mounted on `/mnt/`
  - Selected directories & files within `/home/`

13.4.2 Backup all LUKS header to another encrypted drive

https://wiki.archlinux.org/title/Dm-crypt/Device_encryption#Backup_and_restore

```
doas cryptsetup luksHeaderBackup /dev/<device> --header-backup-file
/mnt/BACKUP/Linux/keys/luksHeader_root.img
```

14 Maintenance

https://wiki.archlinux.org/title/System_maintenance

14.1 Removing unused packages

https://wiki.archlinux.org/title/Pacman/Tips_and_tricks#Removing_unused_packages_(orphans)

14.1.1 Remove unneeded dependencies (using paru)

```
paru -c
```

14.1.2 Check if you need certain packages

```
pacman -Qtdq
> Yes: doas pacman -D --asexplicit <packages>
```

14.1.3 Recursively removing orphans and their configuration files

```
pacman -Qtdq | doas pacman -Rns -
```

14.1.4 Detect & Remove more unneeded packages

https://wiki.archlinux.org/title/Pacman/Tips_and_tricks#Detecting_more_unneeded_packages

```
doas pacman -Qqd | pacman -Rsu --print -
> Remove: doas pacman -Rns <packages>
```

14.2 Pacnew and Pacsave

READ: https://wiki.archlinux.org/title/Pacman/Pacnew_and_Pacsave

14.2.1 Managing .pac* files – pacdiff (using vimdiff)

```
doas pacdiff
```

> Repeat: `View / Skip / Remove pac* file`

- **Change window** to your current config file: `Ctrl+w > w`
- **Repeat:**
  - **Jump to the next change:** `] > c`
  - **OPT: Get changes** from other into current window: `d > o` (diff obtain)
- **Save & Quit your config file:** `:x!`
- **Quit pac* file:** `:q`

14.3 Free up disk space

14.3.1 Tools

https://wiki.archlinux.org/title/List_of_applications/Utilities#Disk_cleaning
https://wiki.archlinux.org/title/List_of_applications/Utilities#Disk_usage_display

- **KDE disk usage statistics:** `filelight`
- **KDE system cleaning:** `sweeper`
- **Duplicate finder:** `fclones`

14.3.2 Remove all cached versions of uninstalled packages

```
doas paccache -ruk0;
```

14.3.3 Clean ~/cache/

```
rm -rf ~/.cache/*;
```

14.3.4 Clean cache from other applications

Note: Not fully tested.

```
rm -rf ~/{.bundle,.cargo,.cmake,.dotnet,.electron,.electron-
gyp,.gem,.gradle,.lazarus,.node-
gyp,.npm,.nuget,.nvm,.racket,.rustup,.stack,.yarn} || true;
```

14.3.5 Tip – Print est. file space usage (using du)

Files sorted by size "MiB" from ~/cache/ with depth ≤1:

```
du -md1 ~/.cache/ | sort -n;
```

14.4 Btrfs

14.4.1 Verify structural integrity

https://btrfs.readthedocs.io/en/latest/btrfs-check.html

Note: `--force` for mounted & quiescent filesystems.

```
doas btrfs check -p --force /dev/mapper/root
```

> Errors found?
> Backup data **&**
> Attempt to repair unmounted FS with `--repair` ELSE reformat.

> No error found? > Verify checksums of data blocks & wait:

```
doas btrfs check --check-data-csum -p --force /dev/mapper/root
```

14.4.2 Making block group layout more compact

https://btrfs.readthedocs.io/en/latest/btrfs-balance.html#making-block-group-layout-more-compact

The Btrfs chunks are usually not filled with only used data, see:

14.4.2.1 List allocation of block group types of the mounted (root) fs

```
btrfs filesystem df /
```

> Example:

```
Data, single: total=1.59TiB, used=1.42TiB
System, DUP: total=8.00MiB, used=208.00KiB
Metadata, DUP: total=30.00GiB, used=3.15GiB
GlobalReserve, single: total=512.00MiB, used=0.00B
```

14.4.2.2 Calculate used/total ratio

… to check if balancing is worthwhile.

Here: The **d**ata chunks of the root mount point are filled by 91% on average, and **m**etadata chunks by 10.5%.

14.4.2.3 Start balancing w/ filters for a faster process

Note: Only use `-musage=70` **if** the metadata used/total ratio is really off (like in the example).
Tip: Set `-dusage=90` for SSDs.
Note: If you get an "Error: No space left on device (ENOSPC)", use `-dusage=0`.

```
doas btrfs balance start -dusage=85 -musage=70 --bg /
```

Check balancing status:

```
doas btrfs balance status /
```

Result – Here: w/ `-dusage=90 -musage=70` after 8 minutes:

```
Data, single: total=1.44TiB, used=1.42TiB
System, DUP: total=32.00MiB, used=208.00KiB
Metadata, DUP: total=4.00GiB, used=3.13GiB
GlobalReserve, single: total=512.00MiB, used=0.00B
```

14.5 Fix pacman warning: Directory permissions differ

14.5.1 Example: Warning

```
warning: directory permissions differ on /var/lib/libvirt/swtpm/
filesystem: 755  package: 711
```

14.5.2 Change permissions

https://wiki.archlinux.org/title/File_permissions_and_attributes#Changing_permissions

```
doas chmod 711 /var/lib/libvirt/swtpm/
```

15 Troubleshooting

https://wiki.archlinux.org/title/General_troubleshooting

Note: You can always restore from a btrfs snapshot.

15.1 Downgrading packages

https://wiki.archlinux.org/title/Downgrading_packages

```
doas pacman -U /var/cache/pacman/pkg/<old_pkg>.pkg.tar.zst
doas pacman -U ~/.cache/paru/clone/<aur-pkg>/<old_aur-pkg>.pkg.tar.zst
```

15.2 Check for errors (also for maintanance)

https://wiki.archlinux.org/title/System_maintenance#Check_for_errors

15.2.1 Logs

15.2.1.1 Error, critical & alert priority messages from last boot

```
journalctl -p3 -b-1
```

15.2.1.2 Failed systemd services

```
systemctl --failed
```

15.2.1.3 Pacman

```
less /var/log/pacman.log
```

15.2.1.4 KDE GUI

```
ksystemlog
```

15.2.2 Analyze boot times

15.2.2.1 Basic startup time

```
systemd-analyze time
```

15.2.2.2 List of all running units, ordered by initialization time

Note: Output might be misleading as the initialization of one service might be slow simply because it waits for the initialization of another service to complete.

```
systemd-analyze blame
```

15.3 Useful keyboard shortcuts

15.3.1 Switch to n-th virtual console

… e.g. to avoid hard shutdowns (holding down the power button).

> Switch: `Ctrl + Alt + Fn + { F1, F2, …, FN }`

> Login as *username*

15.3.2 Kernel (SysRq)

https://wiki.archlinux.org/title/Keyboard_shortcuts#Kernel_(SysRq)

… e.g. to avoid hard shutdowns, or to kill a memory-hogging process.

Note: The key `[SysRq]` is often `[Fn]+[Print]`.

15.3.2.1 Enabling

```
doas vim /etc/sysctl.d/99-sysctl.conf
> kernel.sysrq = 128
```

15.3.2.2 Rebooting

"**R**eboot **E**ven **I**f **S**ystem **U**tterly **B**roken":
`Alt + Fn + Print + { R > E > I > S > U > B }`

15.3.2.3 Killing a memory-hogging process

`Alt + Fn + Print + F`

15.4 Common problems

15.4.1 Pacman: "invalid or corrupted package PGP signature"

https://wiki.archlinux.org/title/Pacman/Package_signing#Upgrade_system_regularly

… if the system upgrade has been delayed for an extended period of time.

```
doas pacman -Sy archlinux-keyring && doas pacman -Su;
```

15.4.2 Audio problems > Try:

```
rm -rf ~/.local/state/wireplumber/;
```

```
systemctl restart --user pipewire-pulse.socket pipewire-pulse.service
pipewire.socket pipewire.service wireplumber.service
```

15.4.3 KDE upgrade problems > Clean cache

https://wiki.archlinux.org/title/KDE#Clean_cache_to_resolve_upgrade_problems

```
rm ~/.config/Trolltech.conf;
kbuildsycoca6 --noincremental;
```

```
OPT: rm -rf ~/.cache/*;
```

16 TODOs

16.1 Additions

- Hardening of mount points
- More Trusted Platform Module (TPM) integration
  - systemd-cryptenroll w/ TPM-PIN, but is currently not stable: [1], [2]
- Better btrfs checksumming for collision resistance
- Maintenance: Old configuration files, Broken symlinks, List packages by date
- Maybe: Restrict unprivileged user namespaces, but selectively allow for some apps (e.g. Steam) with AppArmor's unprivileged_userns_restriction > Similar to firejails `restrict-namespaces`
- locate: Include btrfs mountpoint like ~/, but exclude e.g. /.snapshots/
- Maybe: Use run0 (w/o SUID) instead of doas, sudo or sudo-rs
  Waiting for polkit v127
- uutils-coreutils instead of coreutils
  Not ready to substitute coreutils yet
- Better alternative to sed, as no warning is issued if no lines have been changed

16.2 Deprecations

- Multilib repo (32-bit)
  Waiting for Steam
- Xwayland
  Currently, no or incomplete implementation of Wayland in: Steam, OpenJDK, DisplayCal, …

16.3 Current bugs & misbehavior

- **Current typical error messages:**
  `- systemd-cryptsetup: Could not extend NvPCR: No such file or directory`
  `- dbus-broker-launch: Activation request for 'org.freedesktop.nm_dispatcher' failed.` … when the computer is shut down.
- **systemd:** A message "You are in emergency mode" will appear two minutes after you have not yet entered your `crypt_password`. Simply ignore this warning by pressing `Enter`.
  This is caused by GPT partion automounting: "Timed out waiting for device /dev/gpt-auto-root."
- **mkinitcpio:** Emergency shell is not fully disabled
  Since the root account in initramfs is locked because of mkinitcpio's `systemd` hook, there is no working emergency shell anyway.
- **Kernel lockdown** disallows hibernation/suspend despite having encrypted swap.
  `$ fwupdmgr security` prints the "Linux swap" as "Invalid".
- **Steam** does not have GameMode integration. You have to use "gamemoderun %command%".

16.4 Changelog

- **Update:** Steam
  - **New:** Add infos about Proton & notable compatibility tools
  - **New:** Add infos